the Petroleum Engineer

A Magazine of Methods for Operating Men

SEPTEMBER • 1948

VOLUME XIX NUMBER 13

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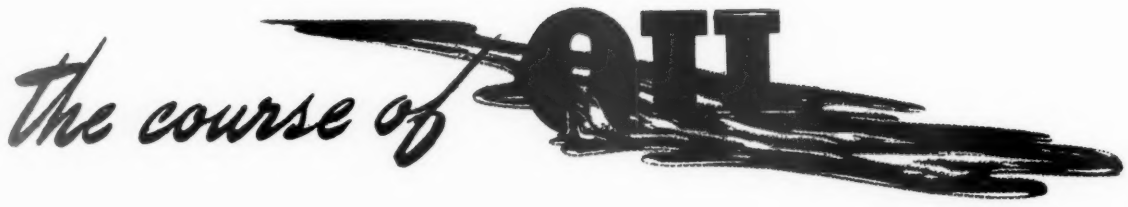


LATENT OIL RESERVES

An unprecedented postwar demand for oil much greater than had been anticipated now besets the industry. To keep pace with the inordinate demand, adequate additions to domestic oil reserves, both by new discoveries and by improvements in production practice, become vitally essential. Exploratory drilling could be stepped up were more steel available, but shortages are still to be reckoned with. Because of them, there has been a slowing down of exploratory drilling activity. In many instances, exploratory drilling programs have been held in abeyance and in some instances abandoned.

The production branch of the industry can render valuable aid in supplementing available domestic reserves. One of the most promising means is by a more intensive application of secondary recovery methods. As a means of increasing ultimate oil recovery from stripper fields, secondary recovery warrants much wider consideration than has been accorded it. When substantial additions can positively be made to the available domestic oil reserve by a more general adoption of this practice, efforts with this in view merit attention.

What erroneously might be construed as apathy on the part of the industry toward wider application and adoption of secondary recovery methods is probably due in large part to the preliminary cost involved and the time necessary to obtain a return on the capital investment required. It takes time and money to put large scale secondary recovery projects into full operation. Secondary recovery operations are usually long range projects and months or years may elapse before results are attained in the form of increased production of oil in substantial and steady volume. When the price of oil is low, as it has been for years until recently, embarking on a large scale secondary recovery project can be a very profitless venture, for the margin between profit and loss is, more often than not, quite thin. It is imperative that a secondary recovery project, to be profitable, be well engineered.

The industry is and has been for years well aware of the possibilities of secondary recovery and the potential increases of oil that are possible. It is not surprising, therefore, that an increasingly greater interest in this method of production is in evidence throughout the industry.

A nationwide study now being made of the nation's producing fields and their secondary recovery possibilities indicates that a very substantial increase in available domestic oil reserves is possible. It is believed that the ultimate recovery could be increased by an estimated five to seven billion barrels of oil—at least this much. This, mind you, is a conservative estimate. The volume of this increase is more than equivalent to the discovery of another East Texas field. It is equal to three years' domestic supply of oil at present rates of consumption. This surely is sufficient justification for embarking on intensive research programs—for there are many problems—looking to the improvement and wider application of secondary recovery methods.

The Petroleum and Natural Gas Division of the U. S. Bureau of Mines has a secondary recovery group for production research on secondary recovery from stripper oil fields.

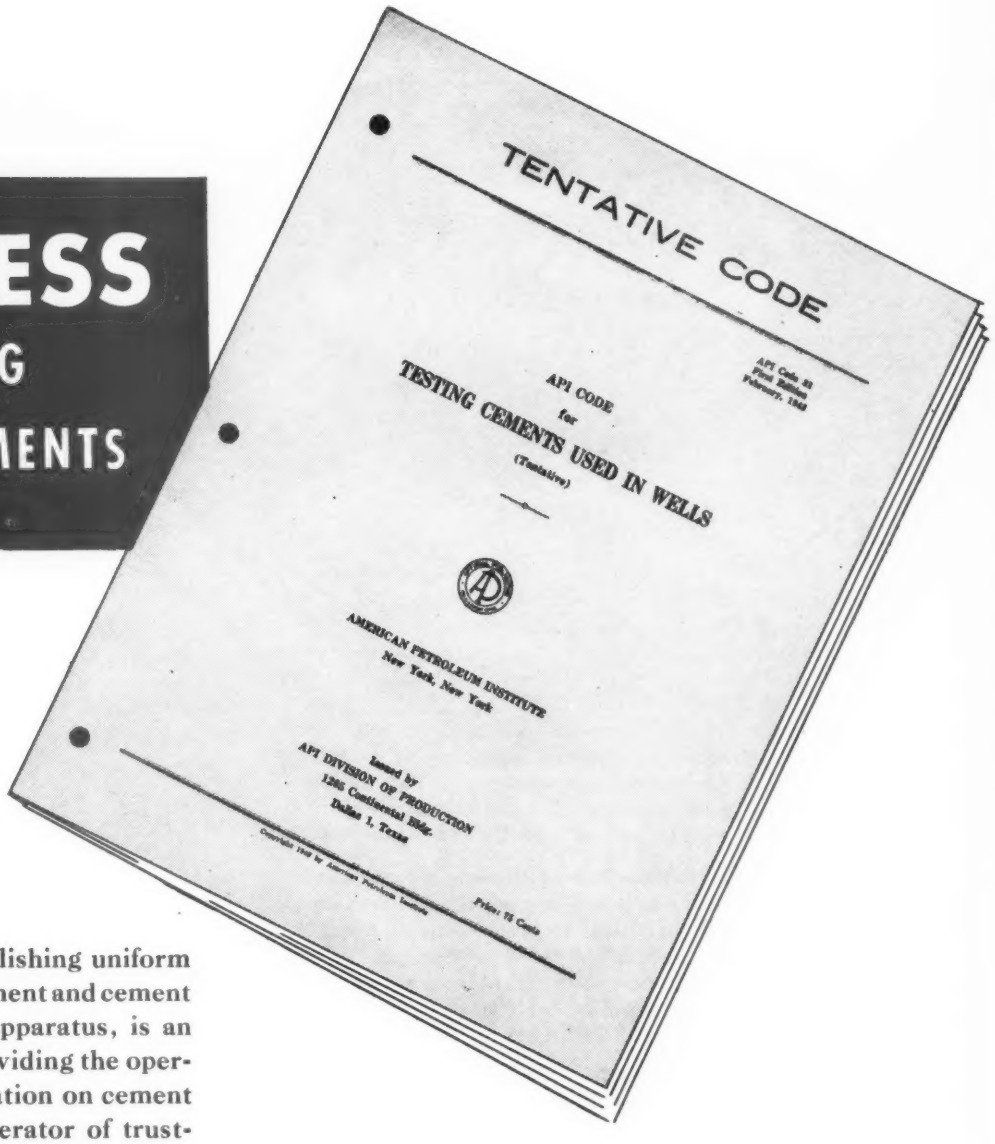
An innovation in State cooperation is the recent formation of the Texas Petroleum Research Committee, sponsored jointly by the University of Texas and the Agricultural and Mechanical College of Texas, in cooperation with the Railroad Commission of Texas. Its purpose is to increase production of Texas petroleum. The program of research in petroleum planned will lay particular emphasis on problems of secondary recovery of oil, as well as on improvements in primary recovery methods. Five members are on the Committee, two representatives from the University of Texas, two representatives from the Agricultural and Mechanical College of Texas, and one representative from the Railroad Commission of Texas. All five members are graduate petroleum engineers and each has a rich background of practical experience in the development and production of oil and gas.

Oil companies themselves are also carrying on intensive research on secondary recovery problems. This work is coordinated by an industry-wide committee within the Production Division of the American Petroleum Institute. Valuable data on secondary recovery have been gathered over a period of several years.

An advisory committee for the study of secondary recovery was set up last year by the Interstate Oil Compact Commission. The field work is in the hands of a competent petroleum engineer of the Commission.

Pooling the experience of these various groups it is hoped will result in increasingly vigorous efforts to produce the latent reserves of oil now lying in the stripper fields throughout the country. —K.C.S.

PROGRESS
IN TESTING OIL WELL CEMENTS



THE new API Code, establishing uniform procedures for testing cement and cement slurries, with standardized apparatus, is an important forward step in providing the operator with dependable information on cement properties. It assures the operator of trustworthy test data, as an aid to practical experience in selecting the right cement to fit a given set of job conditions...which, in the final analysis, is one of the most vital factors in obtaining a first-class cementing job. Our Oil-Well Cement Research Laboratory has always taken an active part in developing sound testing procedures. The new Code is a milestone in oil-well cementing progress.

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SELECT CEMENT TO FIT THE JOB

SCANNING WASHINGTON'S OIL HORIZON

By MILBURN PETTY

WASHINGTON—More than half a dozen studies are now under way to develop a national oil policy—but there is little being done to coordinate these efforts of government agencies, congressional committees, and industry groups.

President Truman, in rejecting the idea of a presidential commission to develop a national oil policy, said a number of government agencies were already at work on such a project. But nothing was said about coordinating the reports being prepared. And little has been done in that direction, although NPC's national oil policy committee (headed by A. Jacobsen, Amerada) has requested copies of all reports.

▸ **OIL POLICY REPORTS.** One of the last assignments of Wallace Pratt (SONJ) as petroleum adviser to the National Security Resources Board was to prepare an oil policy report. It was completed and put on ice, classed as "secret." Supposedly, it covers the entire field, with recommendations, including an elaboration of the DeGolyer idea of bringing in foreign oil and trading it for reserves in place.

Another oil policy report, from the military angle, was that prepared by the Armed Services Petroleum Board at the request of Defense Secretary Forrestal. This report is understood to cover all phases of the petroleum situation, domestic and foreign, including synthetics, stockpiling, imports vs. exports, the need for a strong domestic oil industry, desirability of developing nearby foreign sources—particularly Mexico, importance of Middle East oil, etc.

Foreign aspects of oil policy are covered in a report by the State Department's International Petroleum Policy Committee, still pending in committee because Interior's representative objected to sending it up the ladder to the White House unless and until the industry, through the NPC, had been given a chance to state its views.

Interior Department itself is preparing a "white paper" on oil, at the request of the White House. At first it was to be a "quickie" study designed to head off the increasing congressional demand for a presidential oil commission to make a comprehensive study as the Baruch Committee did on rubber in 1942. Now, it has been broadened out but won't be pushed by Interior unless the White House prods them.

▸ **CONGRESS STUDIES OIL POLICY.** Leading congressional committees working on national oil policy are Senator Malone's Natural Resources Committee and Congressman Wolverton's House Interstate Commerce Committee. Malone's committee will open hearings on October 5 with the intent of developing a program to assure a strong domestic oil industry—including synthetic fuels—which will include protection against the impact of foreign oil. He is sponsoring legislation now for an "import fee" to equalize production costs here and abroad. Wolverton, more inclined to be critical of the oil industry than Malone, is working on an overall policy report that will feature discussion of prices and means of furthering the development of Mexican oil.

Wolverton's committee recently returned from a two-week trip to Mexico, much impressed with the activities of Petroleos Mexicanos, the government-owned company that has operated the expropriated oil properties since 1938.

Wolverton said he was "hopeful" that the committee's trip "will result in some satisfactory procedure for developing Mexico's oil resources in accordance with Mexico's law." He did not say how this might be done. Press dispatches from Mexico mentioned a $45,000,000 loan.

▸ **CO-OPS SEEK WORLD OIL POLICY.** The American delegation to the International Co-operative Alliance, meeting in Prague late in September, will propose that the United Nations Organization make a study of world oil resources and how they can be best administered for the benefit of all peoples, the "have" and the "have not" nations alike. It was at a meeting of this co-op group two years ago that the proposal for world oil control by the United Nations was first advocated. Later, UN rejected the idea.

The co-ops are bringing in their first cargo of Middle East oil this month, with another to follow in November, purchased from Anglo-Iranian at the Persian Gulf. Howard Cowden, Kansas City, president of the Consumers Co-operative Association, says that this crude can be laid down in the Middle West (or exchanged for Mid-Western crude) at competitive prices.

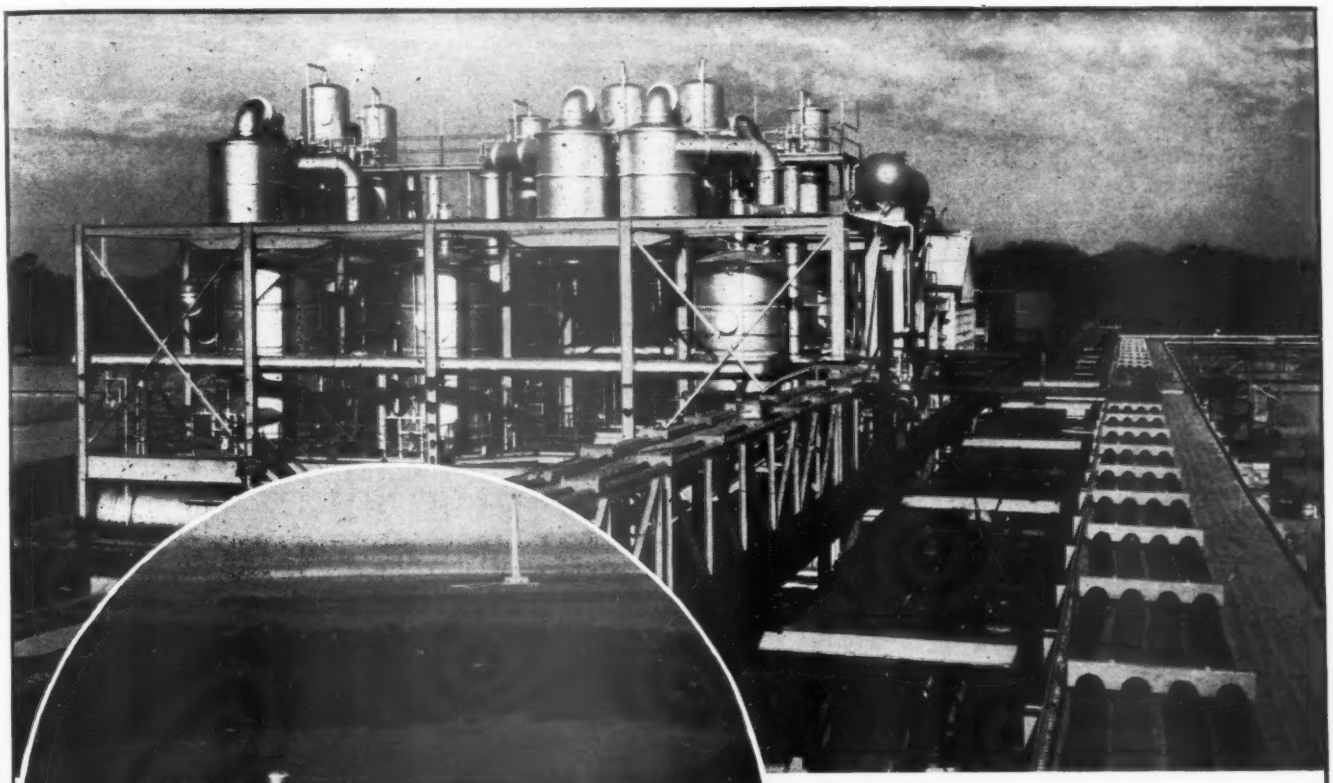
Meanwhile, the co-ops are hiring a high powered lobbyist to call personally on the two leading presidential candidates, President Truman and Governor Dewey, to urge that they pledge opposition to quitclaiming the tidelands to the States. (Truman needs no urging on this score. Dewey's personal views have not been announced, although the Republican Platform favors revesting the states with tidelands title.)

▸ **VOLUNTARY OIL PLAN.** The tight supply situation that followed in the wake of the California strikes has more than ever convinced the industry's statisticians that it isn't safe to say "the oil shortage is over" without tacking on a number of "IFs." But it has served to demonstrate the wisdom of having a voluntary petroleum allocation plan ready and industry committees set up to run it in event spot shortages do occur; also, to adjust refinery yields to increase the output of kerosine and distillates.

The military's difficulties in obtaining coverage for its requirements appear to be ended, with increased offerings from the industry.

Another effort is being made to build a pipe line from West Texas to Los Angeles. This time it is by Texas-Western Oil Lines, Inc., headed by J. S. Jenner, Washington, who handled disposal of the Big Inch pipe lines for the War Assets Administration, and Charles H. Smith, New York, leading oil bidder for the Big Inch lines. Jenner and Smith insist that they have commitments for the necessary pipe (24-in.), enough crude in sight to operate the line at minimum capacity of 150,000 bbl a day and "plenty of customers" for the crude at the California end of the line.

Interior Department is finalizing its new rules for sale of government royalty oil under the O'Mahoney Law, which gives preference to small refiners without an adequate crude supply. Aim is to award the oil to independent refiners at the posted field price on the basis of who needs it the most.



WE'RE PROUD OF DIAMOND'S NEWEST CHEMICAL WORKS

Diamond Alkali Company's newest chemical plant, the Houston Works on the Houston Ship Channel, recently went on stream, manufacturing chlorine and caustic for what it's able young president, R. F. Evans, so aptly described as "the living, growing, expanding chemical industry." Brown & Root, Inc. are proud to have been selected for engineering and construction of this great plant—proud of the part we have in the process industry in the Southwest, which is fast securing its position as a world chemical capital.

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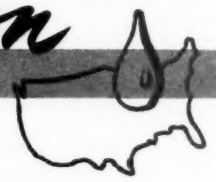
national petroleum situation



By H. J. STRUTH*,
Petroleum Economist

OVER-OPTIMISM UNWARRANTED. While the oil industry is doing a remarkable job in meeting the high demand for its products, it is decidedly premature to give widespread publicity to over-optimistic statements concerning the oil supply outlook. Talk of "abundance" at this time could set off a new wave of coal to oil burner conversions, which would quickly dissipate existing stock accumulations.

SUPPLY-DEMAND OUTLOOK. Winter demand for products is expected to show an increase over last winter of about 7 per cent, to a daily average of 6,720,000 bbl. Foreseeable supply will be about 6,726,000 bbl daily, including a stock carry-over equivalent to 146,000 bbl daily during the winter period. The "excess" above anticipated demand is only 6,000 bbl daily, which is little to "crow" about, particularly in the face of a new labor strike in California. THE PETROLEUM ENGINEER has consistently differed with official Washington reports of alarm over the oil supply, both for the past summer and the coming winter, but has not seen any reason thus far to take down the storm signals.

HIGH DEMAND AHEAD. Peak gasoline consumption ended with Labor Day, but the winter season ahead is expected to bring new demand peaks for products. Summer demand for petroleum products averaged about 6,136,000 bbl daily, but demand in the winter season, ending with March 31, 1949, will be about 9½ per cent greater, with a projected daily average demand of 6,720,000 bbl. While the demand for gasoline will be about 300,000 bbl less during the winter months, the demand for fuel oils is expected to increase about 775,000 bbl daily. Kerosine demand will also be greater by more than 160,000 bbl daily.

NEW DRILLING PEAK. Well completions, exclusive of service wells, are expected to reach an all-time peak this year of close to 37,000. This will mark a gain over 1947 of over 5,900 wells. Completions through August totaled 23,308, which is an increase over the same period of last year of 16 per cent. Completions over the balance of this year are expected to average over 3,400 wells monthly. Wildcat drilling this year is likely to show an increase of about 1,300. Completions may total 6,500 against 5,201 in 1947.

*Editor, *The Petroleum Data Book.*

Comparative Statistics, August, 1948

*All figures are computed on a Bureau of Mines' Basis**

	August 1948℗	July 1948℗	August 1947	This year to date	Last year to date	Per cent change
Wells drilling	4,790	4,760	4,440	4,790	4,440	+ 8
Total wells drilled	3,564	3,499	3,250	24,670	21,398	+15
Development wells	2,781	2,732	2,554	19,299	16,783	+15
Oil	1,871	1,818	1,670	13,409	11,225	+19
Gas	258	239	305	1,618	2,094	−29
Dry	652	675	579	4,272	3,464	+23
Per cent dry	23.4	24.7	22.7	22.1	20.6	+ 1.5
Service wells	155	173	202	1,362	1,339	+ 2
Wildcat wells	628	594	494	4,009	3,276	+22
Oil	106	117	89	631	517	+22
Gas	26	21	22	173	128	+35
Dry	496	456	383	3,205	2,631	+22
Per cent dry	79.0	76.8	77.5	79.9	80.3	− 0.4
Crude supply*	182,050	181,110	168,607	1,406,433	1,274,098	+10
Daily average	5,873	5,842	5,439	5,764	5,243	
Crude demand‡	181,440	183,060	170,946	1,406,787	1,270,431	+11
Daily average	5,853	5,905	5,514	5,766	5,228	
Crude stocks	230,300	229,690	233,843	230,300	233,843	− 2
Days supply	39	39	42	39	42	
Natural gasoline production	11,940	12,100	11,204	94,891	85,111	+11
Daily average	385	390	361	389	350	
Motor fuel production	80,880	81,550	75,745	607,968	544,085	+12
Daily average	2,606	2,631	2,443	2,492	2,239	
Gasoline yield, per cent	41.2	41.1	41.3	39.9	39.8	+ 0.1
Motor fuel demand‡	85,244	86,474	75,978	602,437	551,596	+ 9
Daily average	2,750	2,789	2,451	2,469	2,270	
Motor fuel stocks	93,010	97,374	82,207	93,010	82,207	+13
Days supply	34	35	34	34	34	
Fuel oil production	71,170	71,280	65,538	567,165	491,304	+15
Daily average	2,296	2,299	2,114	2,324	2,022	
Fuel oil demand‡	61,308	62,461	60,176	588,284	552,151	+ 7
Daily average	1,978	2,015	1,941	2,411	2,272	
Fuel oil stocks	131,510	115,698	106,041	131,510	106,041	+24
Days supply	66	57	55	66	55	
Refinery still runs	174,050	176,300	163,068	1,350,022	1,205,044	+12
Daily average	5,615	5,687	5,260	5,533	4,959	
All refined stocks	321,350	305,870	276,813	321,350	276,813	+16
Days supply	55	52	51	55	51	

Supply and Demand—All Oils

	August 1948℗	July 1948℗	August 1947	This year to date	Last year to date	Per cent change
Total supply, all oils	198,120	197,440	183,685	1,541,185	1,401,346	+10
Daily average	6,391	6,369	5,925	6,316	5,767	
Total demand‡, all oils	182,030	186,213	172,913	1,490,762	1,397,784	+ 7
Daily average	5,872	6,007	5,578	6,110	5,752	
Change in stocks	+16,090	+11,227	+10,772	+50,423	+3,562	

Current Crude Oil Prices

U. S. average	$2.61	Louisiana	$2.62
Texas	2.61	Arkansas	2.43
California	2.42	New Mexico	2.40
Oklahoma	2.63	Mississippi	2.42
Kansas	2.62	Illinois	2.76
		Other states	3.15

Basic crude prices:

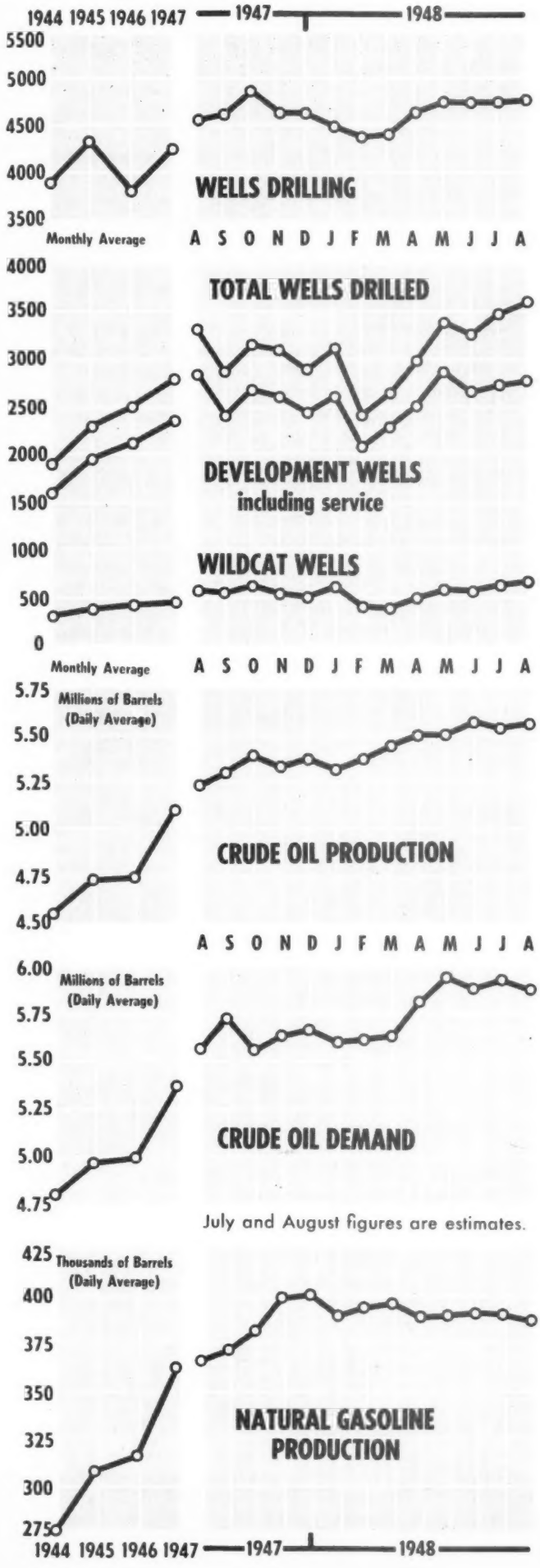
Oklahoma-Kansas (36 gr.)	$2.57
Texas Gulf Coast (36 gr.)	2.86
East Texas	2.65
West Texas (36 gr.)	2.44
California Signal Hill (26 gr.)	2.41
Pennsylvania, Bradford	5.00

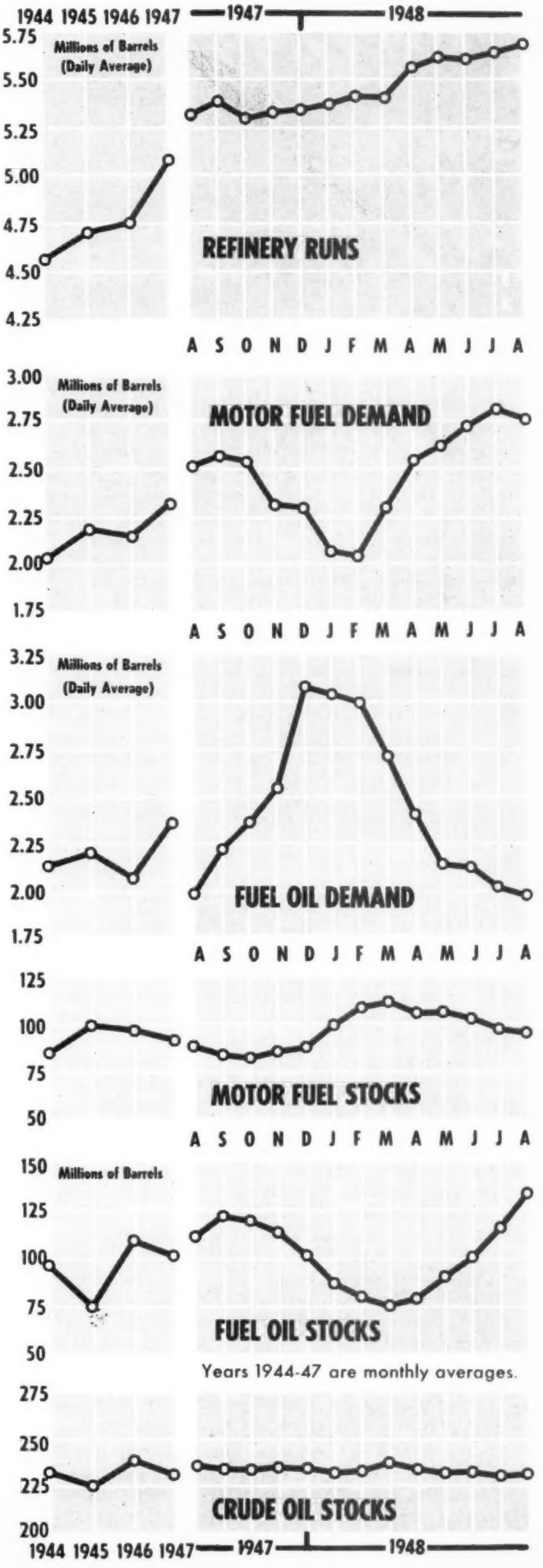
Drilling and Production Statistics by States

	August 1948℗	July 1948℗	August 1947	This year to date	Last year to date	Per cent change
Wells drilled (excl service)	3,409	3,326	3,048	23,308	20,059	+16
Arkansas	31	20	29	196	192	+ 2
California	264	242	149	1,909	1,279	+49
Illinois	225	246	194	1,504	1,301	+16
Kansas	262	294	242	1,981	1,625	+22
Louisiana	213	234	180	1,472	989	+49
Mississippi	44	35	51	268	333	−20
New Mexico	47	51	50	401	360	+11
Oklahoma	392	343	352	2,676	2,575	+ 4
Texas	1,077	1,116	937	7,641	6,228	+23
Other states	854	745	864	5,260	5,177	+ 2
Wildcats drilled	628	594	494	4,009	3,276	+22
Arkansas	16	6	5	68	40	+70
California	55	49	22	292	226	+29
Illinois	55	49	39	270	285	− 5
Kansas	53	53	40	330	259	+27
Louisiana	34	29	31	197	185	+ 6
Mississippi	16	7	7	65	60	+ 8
New Mexico	5	6	3	40	29	+38
Oklahoma	72	68	78	543	531	+ 2
Texas	236	250	181	1,650	1,200	+38
Other states	86	77	88	554	461	+20
Daily crude production	5,550	5,520	5,173	5,456	4,977	+10
Arkansas	85	85	81	86	81	+ 6
California	947	948	918	942	907	+ 4
Illinois	179	172	175	174	184	− 5
Kansas	310	308	295	300	285	+ 5
Louisiana	502	495	443	487	429	+14
Mississippi	128	124	99	122	91	+34
New Mexico	133	132	118	129	108	+19
Oklahoma	425	427	384	414	378	+10
Texas	2,461	2,455	2,315	2,434	2,183	+11
Wyoming	154	151	120	146	116	+26
Other states	226	223	225	222	215	+ 3

*Unless otherwise stated all figures represent thousands of barrels.
‡Total demand, including exports.
℗–Preliminary.
△Includes finished and natural gasoline.
*Includes domestic production and imports.
¶Revised.

Preliminary estimates based upon data supplied by American Petroleum Institute, U. S. Bureau of Mines, State Agencies, and other official sources.


1944 1945 1946 1947
1947
1948
WELLS DRILLING
Monthly Average
A S O N D J F M A M J J A
TOTAL WELLS DRILLED
DEVELOPMENT WELLS
including service
WILDCAT WELLS
Monthly Average
A S O N D J F M A M J J A
Millions of Barrels
(Daily Average)
CRUDE OIL PRODUCTION
A S O N D J F M A M J J A
Millions of Barrels
(Daily Average)
CRUDE OIL DEMAND
July and August figures are estimates.
Thousands of Barrels
(Daily Average)
NATURAL GASOLINE
PRODUCTION
1944 1945 1946 1947
1947
1948


1944 1945 1946 1947
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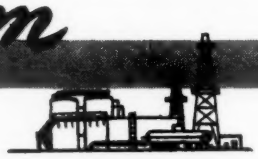
1948
Millions of Barrels
(Daily Average)
REFINERY RUNS
A S O N D J F M A M J J A
Millions of Barrels
(Daily Average)
MOTOR FUEL DEMAND
A S O N D J F M A M J J A
Millions of Barrels
(Daily Average)
FUEL OIL DEMAND
A S O N D J F M A M J J A
MOTOR FUEL STOCKS
A S O N D J F M A M J J A
Millions of Barrels
FUEL OIL STOCKS
Years 1944-47 are monthly averages.
CRUDE OIL STOCKS
1944 1945 1946 1947
1947
1948

highlights in oildom



POGUE'S INDUSTRY STUDY. Although the financial results of the petroleum industry in 1947 showed marked upward changes from 1946, these increases "are revealed to be temperate in the light of vastly increased capital requirements and with due regard to the purchasing power of the dollar," according to a study, "Financial Analysis of Thirty Oil Companies for 1947," which has been issued by the Chase National Bank. For the first time, the financial results are presented not only in "current" dollars but also in "prewar" dollars, thus measuring the effects of inflation on the petroleum industry's operations.

This annual review, prepared by Joseph E. Pogue, vice president in charge of the bank's petroleum department, and Frederick G. Coqueron, staff associate, supplements previous reports and provides a continuous series of data for the 14-year period 1934-1947 on a group of companies which represent about two-thirds of the aggregate investment of the industry. The new booklet, more comprehensive than those of previous years, contains 21 tables and 7 charts as a part of its 30 pages of text.

In the second year of peacetime operations, the study finds, the petroleum industry in 1947 was challenged with a rise in demand for its products representing an increase of 569,000 bbl per day or 1 per cent over 1946.

This impelled the industry to approach capacity operations, exceeding those of the wartime peak; stimulated an advance in petroleum prices, resulting in sharply increased gross and net income; and accelerated the development of a vast expansion program, requiring unprecedented capital expeditures at inflated costs, the study adds.

"Under these circumstances, the dollar income soared but so did the capital requirements. The matching of these two items was so closely achieved that the industry was able to bring about an approximate balance between supply and demand for petroleum products during 1947 and to prepare for a still better position in 1948."

The study discloses that virtually every item of financial and operating results of the 30 companies in 1947 shows a substantial increase over 1946, and a larger advance over the five-year base period, 1941-1945.

In 1947 as compared with 1946, total income amounted to $10,483 millions, an increase of $2,934 millions, or 39 per cent; costs and other deductions totalled $9,264 millions, a rise of $2,478 millions, or 37 per cent, and net income was $1,219 millions, up $456 millions, or 60 per cent. On the other hand cash dividends of $425 millions in 1947 represented an increase of only $94 millions, or 28 per cent, because of the reinvestment in the business of $794 millions, or 65 per cent of the earnings. This relatively large retention was necessitated by a rise of $699 millions, or 51 per cent, in capital expenditures to $2,076 millions in 1947, thus illustrating, the survey emphasizes, "the contribution of the stockholders to the process of capital formation."

"On the whole, this study reveals that the petroleum industry completed the second year of increasing postwar inflation with considerable competence and continued to make effective use of its mechanism of capital formation so essential to expansion," the authors report.

STRIPPER WELL SURVEY. Survey of the nation's stripper well areas to determine the quantity of oil that may be recovered by both primary and secondary production methods now is being made by the Interstate Oil Compact Commission in cooperation with the Independent Petroleum Association of America and the National Stripper Well Association, according to Governor Beauford H. Jester, Compact Commission chairman.

State agencies and consultants now are working in practically every state and it is expected that results of the study may be available late in 1948, Governor Jester said. Information is being gathered by a joint committee of which Don T. Andrus, Bradford, Pennsylvania, chairman of the Compact's stripper well committee, is chairman.

When completed the survey will provide up-to-date data on the number of producing and abandoned wells, productive acreage, production and reserves of every area in the nation. In most instances the information will be by fields.

For the purpose of the study, a stripper well has been defined as one whose cost of operation closely approximates income.

The report will show the areas in which water flooding or other secondary methods of production are being employed and the amount of additional oil that may be obtained by such operations.

EXPORTS LESS THAN IMPORTS. Exports of oil from the United States will be less than imports during 1948, according to R. F. Pielsticker, chairman of the Kansas-Oklahoma Oil Industry Information Committee. This situation has been reversed for the past 25 years, he said.

He quoted a Bureau of Mines forecast which predicted 1948 exports would slightly exceed 6 billion gal, and imports would run more than 7½ billion gal, leaving 1½ billion for domestic use.

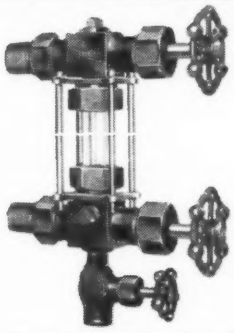
The change has been brought about by the desire among American oil companies to take care of the increased domestic demand for petroleum products, while the industry is catching up with a record expansion program that has been, and is still being delayed by wartime and postwar shortages of materials.

Last year's exports, totaling 6¾ billion gal, represented only 7.7 per cent of America's total oil supply, Pielsticker pointed out. Imports during the same period represented 7.4 per cent, making a net export balance of only three-tenths of 1 per cent of our total supply.

ARABIAN TIDELANDS. A new controversy is arising in the question of tidelands ownership. Only this time it is the Arabian tidelands that are causing the confusion. Superior Oil Company is attempting to obtain from King Ibn Saud a concession to drill off the Arabian coast. It so happens, however, that Arabian American Oil Company maintains that its concession from the King includes the tidelands tract off the Arabian shore in the Persian Gulf waters.

What the attitude of the King will be in the controversy has not yet been made known. Superior has suggested that it may join forces with a British company to develop the offshore area. It is reported that the British concern that might become involved with Superior is the Central Mining Syndicate, which has a controlling interest in Trinidad Leaseholds, Ltd., North Venezuelan Petroleum Co., Ltd., and British Bahamian Oil Development, Ltd. It is headed by Sir Hugh Weightman, and is said to be actively seeking a concession to Saudi Arabian waters.

PENBERTHY
"ALL IRON"
WATER GAGE SET

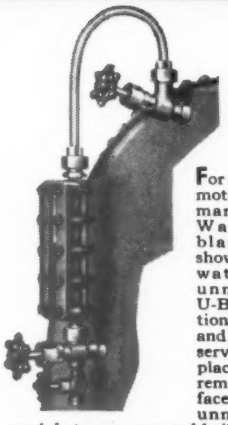


Extra heavy construction throughout. Body made from special high strength alloy iron, shanks alloy steel and trim stainless steel. Automatic and positive shut-off if glass breaks, valves self-cleaning, dripless drain cock permits gradual blowing off of gage. Conforms with A.P.I.-A.S.M.E. requirements.

The Heavy Duty "All Iron" is one of the complete line of Penberthy gages that meets every liquid level gage requirement.

PENBERTHY INJECTOR CO.
DETROIT 2, MICH. Canadian Plant WINDSOR, ONTARIO

PENBERTHY
"REFLEX"
WATER GAGE SET



For oil field, locomotive type and marine boilers. Water shows black — steam shows white; the water level is unmistakable. U-Bolt construction is strongest and simplest to service. Glass replaced by simply removing nuts on face of gage . . . unnecessary to work between gage and boiler. Conforms with A.S.M.E., Federal and State requirements when used for pressures specified by their respective codes.

This is one of the complete line of Penberthy gages that meet every liquid level gage requirement.

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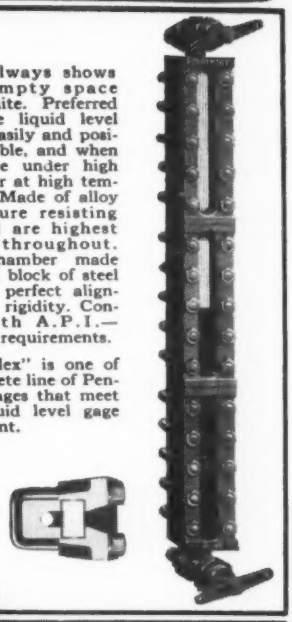
DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

PENBERTHY
"REFLEX"
DROP FORGED STEEL LIQUID LEVEL GAGES

Liquid always shows black—empty space shows white. Preferred where the liquid level must be easily and positively visible, and when liquids are under high pressure or at high temperature. Made of alloy temperature resisting steel and are highest quality throughout. Liquid chamber made from solid block of steel to assure perfect alignment and rigidity. Conform with A.P.I.—A.S.M.E. requirements.

The "Reflex" is one of the complete line of Penberthy Gages that meet every liquid level gage requirement.



PENBERTHY INJECTOR CO.
DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

PENBERTHY
EJECTORS

Use the power of steam, air or water under pressure to lift liquids. Being simple jet pumps they have no moving parts and require no lubrication. A variety of models to meet different conditions. Also used as water heaters.

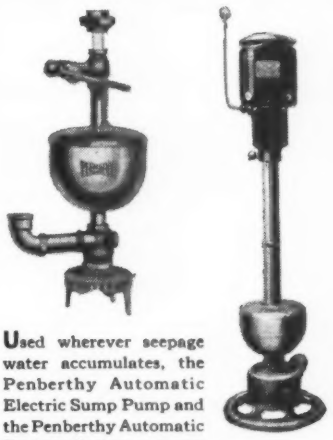
PENBERTHY INJECTOR CO.
DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

PENBERTHY
AUTOMATIC INJECTORS

The accepted method for assuring an uninterrupted supply of feed water to oil field boilers. Penberthy Automatic Injectors will supply feed water to boilers at minimum cost, are quickly and easily installed, reliable under most severe operating conditions, require little attention and no careful handling. Highest quality design and rugged construction.

PENBERTHY INJECTOR CO.
DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

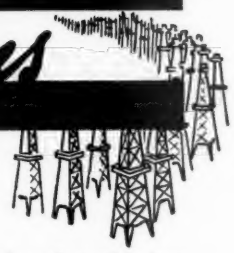
PENBERTHY
SUMP PUMPS



Used wherever seepage water accumulates, the Penberthy Automatic Electric Sump Pump and the Penberthy Automatic Drainer (water or steam operated) have demonstrated their superiority in this service. Simple and rugged design—copper and bronze construction throughout.

PENBERTHY INJECTOR CO.
DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

current oil field operations



Exploration wells that have found production.

KANSAS. J. P. Gaty 1 Brown, Sedgewick. DST est 1000 BOPD Pennsylvania 2957-61 ft.

R. W. Rine Drlg. 1 Earlywine NW SW SW 36-29-14w Pratt. DST 3500 ft 40° oil Simpson 4494-98 ft.

Nat'l. Coop. Refinery et al 1 Smith SE SE SW 8-9-18w Rooks. Swb 35 B oil in 4-hr. Arbuckle 3491-96 ft.

Great Lakes Carbon 1 Werner SW SE SE 21-30-14w Barber. 4-5000 MCF gas daily Simpson 4594 ft.

Consolidated Gas & Anderson-Prichard 1 Bates SE SE SE 26-30-2w Sumner. 4000 MCF gas daily. Mississippi 3771 ft.

Cities Service 158 Chesney CSW SW NE 21-25s-5e Butler. 122 BOPD Douglas 1494 ft.

Cities Service 1-B O'Connor CSE SE 8-24-15w Stafford. 54 BOPD Kansas City 3787 ft.

El Dorado 1 Meier SE SE NW 30-15s-12w Russell. 252 BOPD Arbuckle 3325-31 ft.

Jones-Shelburne 1 Pivonka SE 22-15-18w Ellis. 31 BOPD from Madden.

LOUISIANA. Humble 1 Grand Isle in Gulf off Lafourche. 800 BOPD 30.9° from 8640-65 ft.

California 1 State, lease 1278, blk 69 in Gulf off Plaquemines. 196 BOPD 25° from 5848-58 ft.

Barnsdale 1 Davis Bros. Lbr. 7-16n-4w. Driscoll field, Bienville. 10,800 MCF gas daily Pettit 6760-800 ft.

Union of California 1 LL&E 8-18s-16e Terrebonne. 8 BOPH 36.7° from 7896-902 ft.

Union of California 1-9 State-LL&E 27-21s-14e Terrebonne. 135 BOPD 37.7° from 4012-20 ft.

H. L. Hunt 1 Harry Edwards 78-2n-4e Avoyelles. 180 BOPD 48° Wilcox 7926-32 ft.

Sun 1 Lyric Realty 66-15s-15e Lafourche. 166 BOPD 34.6° from 10,078-98 ft.

OKLAHOMA. Sunray 3-B Romine SW SW NE Southwest Eola, Garvin. 640 B oil in 10-hr. 1639-64 ft. New sand.

Phillips 1 Hutson SE SW SW 3-14n-5w Knox field, Grady. 8 BOPH from 5683 ft. New sand.

Deardorf 1 Howell SW NE SE 14-17n-3e Payne. 5000 MCF gas daily Bartlesville 3900-31 ft.

F. B. Murta 1 Ida Ellis SE NW SE 6-9n-11e Hughes. 3000 MCF gas 100 B oil daily Cromwell 3107-3111 ft.

NEW MEXICO. Texas Pacific Coal & Oil 39-A State, 2, 9-22s-36e Lea. DST gas and 14.6 B 40° oil in 1-hr. Pennsylvanian 10,895-944 ft.

Magnolia 1 Yates Federal, CNE SE 31-9s-36e Lea. Swb 5 BOPH from 4890-94 ft.

Amerada 5-F State 31-19s-37e, Monument field, Lea. DST gas and 41.1° oil Wichita-Albany 7558-641 ft.

Skelly 1 Sims NE NE SW 3-23s-37e Penrose-Skelly field, Lea. 5½ BOPH Drinkard 6420-90 ft. New sand.

WYOMING. Phillips 1 unit SE SW NW 17-34n-76w Converse. 20-min DST 210 ft oil Dakota 8217-33 ft.

Seaboard 37-28, Silver Tip field, Park. 75-min DST 4000 ft 46° oil and 500 MCF gas daily Tensleep 8664-750 ft.

Atlantic well SW SE 25-1s-4e Fremont. DST 1250 MCF gas 7950-88 ft Frontier.

Wasatch 1 Hintze-Government NE SE 18-22n-78w East Allen Lake field, Carbon. Swb 207 BOPD 3923-65 ft Tensleep. New sand.

TEXAS. General Crude 2 W. H. Jackson, 88-1-H&TC, Fisher. 347 BOPD from 4835-63 ft.

Shell 1 Hedrick, 4-mi. E. of Sulphur Bluff field, Hopkins. 118 BOPD Paluxy 4500-6 and 4525-50 ft.

Sun 3 E. T. Day, Madison. 41.8 BOPD 25° from 1903-8 ft.

T. Payne and Assoc 1 D. J. Schwartz, 3-mi. N. of Mercedes, Hidalgo. 2000 BOPD 42° from 7500 ft.

Consolidated 3 Alice Daves blk 14, lge 2, Denton CSL, Wichita. 1051 BOPD 42° Caddo 5184-98 ft.

Cities Service 1 Foster, T-3-S H. P. Ector. 264 BOPD Grayburg 4215 ft.

S. D. Johnson 1 Prideaux, TE&L sur, Archer. 73.5 B 42.7° oil daily Strawn 3007-19 ft.

Sun 1 Emil Schattell, Scurry. 479 BOPD 44° Pennsylvanian 6816-58 ft.

W. H. Hammon & Warren 2-A Cole, blk 10, Palo Pinto CSL, Wichita. 613 B oil in 1-hr. Canyon 2952-63 ft.

Rowan & Texas Gulf 1 Stovall, 18-IG&N, Matagorda. 10 BOPH Frio 6727-30 ft.

Tide Water et al 1 South Marlow Unit CSE SW 27-2n-7w Stephens. Cond. and 4590 MCF gas daily 7902-46 ft; 4.2 B 52.8° cond. per hour and 1830 MCF gas daily 8203-8535 ft.

F. M. Manning 2 Manning-Herrington Unit, blk 230 BBB&C sur, Throckmorton. 144 BOPD Strawn 3918-48 ft.

Jack Grace 1 Jack Grace Ranch, J. C. O'Connor sur, Jack. 168 BOPD Bend conglomerate 5330-75 ft.

Texas & Humble & R. Lowe 1 S. C. Jenkins et al, 4-A-25-PSL, Gaines. 337.5 B 26° oil in 12 hr Devonian 9100-35 ft.

Deep Rock 1 Wright, blk 256 BBB&C sur, Throckmorton. 47 B oil in 8-hr Caddo 4356-62 ft.

Goodstein & Gordon 1 Golden, 25-Young CSL, Young. 35 BOPD from 2602-24 ft.

F. M. Manning 1 King-Richardson BBB&C sur, Throckmorton. 102 B oil in 7½-hr 4695-710 ft Caddo.

R. S. LeSage 1 Will McKeichan blk 4, Comanche Indian Reserve, Throckmorton. DST gas and oil 4480-510 ft Caddo.

Grace and Grace 1 Otis Smith, H. Tucker sur, Clay. 300 B oil in 6-hr 5420-70 ft Caddo.

Shell 1 Hawkins, 15-mi. S. of Seminole, Gaines. DST 117 BOPD 31.5° from 7103-240 ft Clearfork.

Magnolia 1-A TXL, blk 40 T&P sur, Upton. DST gas and oil 9321-45 ft.

COLORADO. G. H. Reasor 1 Burgess SE NE NW 26-3n-30w Rio Blanco. DST 1500 ft 43° oil from 2950-3029 ft.

MEXICO. Pemex well near Tepezintla, Veracruz. 70,026 gal oil daily.

OHIO. Hoover Bros. well, Mary Ann township Licking. 60 BOPD Newburg 2266 ft.

MISSISSIPPI. W. E. Sistrunk 1 Ralph Stanley NE NE 8-9n-7w Wayne. 188 BOPD Eutaw 4945 and 4038 ft.

INDIANA. F. B. Cline 1 H. A. Seipman, Sullivan. 420 B oil in 4 hr Devonian 1965-68; 2032-39 ft.

George S. Engle 1 John Teel SE SW NW 16-3s-11w Gibson. Swb 150 BOPD Waltersburg 1684-1703 ft.

H. L. Cokes 1 Herman Boeke NE NE 6-6s-11w Vanderburgh. 56 BOPD Aux Vases 2562-69 ft.

ILLINOIS. Arvin Drlg. 1 La Dorca Stone NE SE SE 18-4n-9e Richland. 20 BOPD Rosiclare 2025-32 ft.

Vertical Map Maker!

DOWELL'S ELECTRIC PILOT

helps plan completions and workovers

Do you need reliable information on subsurface well conditions to help you plan more productive completion and work over programs?

Look to DOWELL'S ELECTRIC PILOT, the modern scientific device which enables experienced Dowell engineers to give you these *accurate* surveys:

PERMEABILITY PROFILE SURVEYS—to show location, thickness and capacity of permeable zones.

SPINNER SURVEYS—to measure rate of flow of fluids including gas from or into exposed zones or sections.

WATER LOCATOR—to give an accurate location of the points of water entry in wells.

CALIPER SURVEYS—to measure, sharply and accurately, irregularities in the well bore.

See your nearest Dowell station for complete information on the Electric Pilot Services, including the *Selective Acidizing* of chosen zones. Ask also about remedial Plastic Service and Chemical Scale Removal Service for heat exchange equipment. Dowell products include: Jelflake, Paraffin Solvents and Bulk Inhibited Hydrochloric Acid.

PRODUCTION INCREASED, WATER SHUT-OFF

A well in the Hunton lime produced 61 b.o.p.d., and 85 b.w.p.d. Permeability Profile and Water Locator surveys indicated the relative permeability of the exposed zones and the point of water entry. The oil bearing zones were then acidized *selectively* using the Electric Pilot, and by producing the well "pinched in", it flowed 190 bbls./day pipeline oil.

DOWELL INCORPORATED, TULSA 3, OKLAHOMA

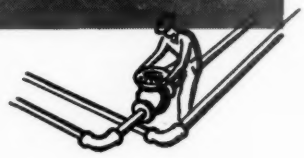
Subsidiary of The Dow Chemical Company

"Petroleum Promotes Progress"

Look to **DOWELL**

FOR OIL INDUSTRY CHEMICAL SERVICE

pipeline developments



APPROVES 3574 MILES GAS LINES. The Federal Power Commission announced that it authorized natural gas companies, during the first six months of 1948, to build 3574 miles of new pipe line, increasing daily delivery capacity by 878,500,000 cu ft. Estimated cost of the expansion is $233,-215,252.

Largest single authorization during the six months was for construction by Trans-Continental Gas Pipe Line Company, Inc., of a 1840-mile line from Texas to New York City, to supply 340,000,000 cu ft of gas daily to utilities in New York, Pennsylvania and New Jersey. Cost is estimated at $151,380,426.

"Comparable figures on an annual basis indicate that during the fiscal year ending June 30, 1948, the commission issued certificates covering 8468 miles of pipe line and installation of compressor units aggregating 531,455 horsepower," the commission said.

"Total estimated cost for the year was $519,945,633."

Since it began issuing certificates in 1942, the commission has authorized construction of 20,456 miles of pipe line and installation of 1,254,739 hp of compressor capacity.

PLANS GAS PLANT. Amarillo Oil Company has contracted with Blaw-Knox Company for construction of a large gas compressor and dehydration plant in Potter County, Texas, about 25 miles north of Amarillo.

The operation of the new plant, scheduled to begin next winter, will mark the first use of compressors to increase the flow of natural gas from the Panhandle gas field to the Amarillo area. According to W. W. Rusk, president of Amarillo Oil, the installation of four 600-hp compressors will enable the delivery of as much as 70,000,000 cu ft of gas per day to Amarillo through the present pipe line system. This is approximately double the present pipe line delivery.

PIPE SHIPPED FROM ENGLAND. Some 100,000 ft of English made oil and gas pipe will move through the port of Houston, Texas, during the coming months, J. B. Strauss, district manager of the L. B. Foster Company, announced recently in Houston.

The Foster company had the pipe made in England for Texas and Southwestern oil and gas companies. It is 24-in., half-in. wall pipe tested for high pressure use.

LINE TO IMPERIAL VALLEY. Southern California Gas Company will build a 73-mile natural gas pipe line connecting with the existing Texas-to-California pipe line near Desert Center, California, and extending into the Imperial Valley to the town of Calexico, California. Cost of the line and facilities is estimated at $1,150,000. Plans are to use 20 miles of used and reconditioned pipe; the remaining 53 miles to be made of new pipe from 4 to 16 in. Completion is set at November 1, 1948.

Gas supplies for the new line are to be obtained from the 1200-mile natural gas pipe line operated by the company and its supplier, El Paso Natural Gas Company, that extends from Texas Panhandle to Los Angeles.

PROPOSES NEW GULF TO EAST COAST LINE. Piedmont Natural Gas Corporation has filed with FPC for authorization to construct and operate a natural gas pipe line system beginning in the upper Gulf Coast gas fields of Texas and Southwest Louisiana and extending through Mississippi, Alabama, Georgia, South Carolina, North Carolina, and terminating in the vicinity of Danville, Virginia. Cost of the project has been estimated at $75,444,000.

As proposed the line would approximate 990 miles in length and would be of 20-in. diam for its entire length. In addition the company proposes construction of 12 compressor stations having a total of 87,000 hp. The capacity of the line would be 215,000,000 cu ft per day.

Piedmont Natural Gas Corporation, Spartansburg, South Carolina, is a new corporation, the company said, recently organized for the sole purpose of constructing and operating the proposed pipe line system for the transportation of natural gas.

CONTRACTS AWARDED. Stanolind Pipe Line Company, Tulsa, Oklahoma, has awarded contracts for the construction of approximately 580 miles of 8-in., 10-in., 12-in., and 16-in. pipe line loops on its main trunk line system in Wyoming, Nebraska, Kansas, Texas, and Oklahoma, according to J. L. Burke, president, in a statement made last month.

Construction is to start immediately and is scheduled for completion before the end of the year. When these new pipe line loops are put in service, Stanolind will be able to increase deliveries by 46,000 bbl per day to refineries served by it.

On the Casper, Wyoming, to Freeman, Missouri, line contracts were awarded to: C. S. Foreman Company to construct 53 miles of 16-in. and 32 miles of 10-in., R. B. Potashnick to construct 64 miles of 16-in., R. H. Fulton and Company to construct 33 miles of 16-in. and 24 miles of 12-in., and to Tom Weadick to construct 35 miles of 12-in. and 70 miles of 8-in. line. Hauling and stringing contracts went to J. L. Cox and Son, to John Bunning Transfer Company, and to Tom Weadick.

On the West Texas to Drumright, Oklahoma, line contracts went to: R. H. Fulton and Company to construct 31 miles of 16-in., Latex Construction Company to build 55 miles of 16-in., Smith Contracting Corporation to construct 51 miles of 16-in., and O. C. Whitaker Construction Company to build 50 miles of 16-in. line. Hauling and stringing will be done by Parkhill Truck Company and J. R. Vandeveer and Son.

CHANGES EXPANSION PLANS. New York State Natural Gas Corporation will construct natural gas pipe line facilities in Pennsylvania at an estimated cost of $3,208,727.

The facilities were authorized by FPC in lieu of certain natural gas pipe line loops. Delay in obtaining the necessary pipe was given by the company as the reason for the change of plans.

Tonkin Compressor Station, Westmoreland County, Pennsylvania, will be built in 1948 at a cost of $890,000. It will contain six 600-hp gas engine-driven compressors and auxiliary equipment.

In addition the company will construct in 1949 a total of 26 miles of 16-in. pipe line parallel to its existing line; approximately 24 miles of 16-in. pipe line north of Rassalas; and about 12 miles of 16-in. pipe line north of Hemphill.

TO ADD COMPRESSOR UNITS. Texas Gas Transmission Corporation plans construction of additional facilities to expand the system capacity of its Memphis division from 185,000,000 cu ft to approximately 200,000,000 cu ft daily. Cost of the new facilities is estimated at $843,000. Facilities include one 1200 hp compressor unit in each of three stations in Mississippi and Arkansas, a new 2000-hp compressor station in Claiborne Parish, Louisiana, and a short line.

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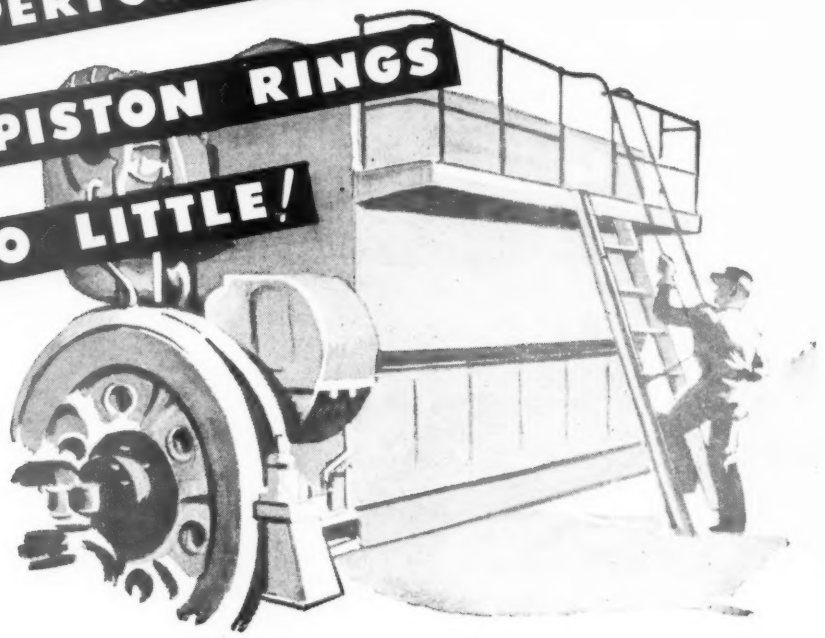

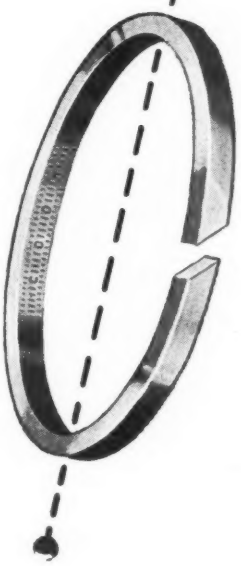

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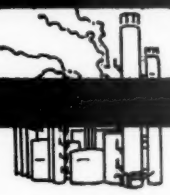


SHELL COMPLETES GLYCERIN PLANT. Spending $8,000,000 on the installation, Shell Chemical Company is nearing completion of its large synthetic glycerin plant at Houston, the world's first plant of its kind to be built, Jan Oostermeyer, Shell Chemical's president, announced recently. The process is expected to be in full operation early in the fall of 1948, it is stated. This process was developed at Shell's research and development laboratories at Emeryville, California, and is based on the conversion of light hydrocarbons, especially propane, to glycerin by oxidation and substitution reactions. Glycerin is tri-hydroxy-propane, and its source heretofore has been as a byproduct of soap production from animal fats.

Glycerin is used widely in modern industry, is in short supply and the new plant's production is expected to relieve this shortage, in part at least.

CONTINENTAL'S REFINERY TO EXPAND. Plans for the expansion of the Ponca City refinery of Continental Oil Company to process 52,000 bbl of crude per day have been announced by the company. This expansion, to cost $7,750,000 and require 18 months to complete, will increase the company's refining capacity to 88,000 bbl per day, it is stated.

The main item in the expansion is the increase of the plant's crude distilling capacity by adding a 30,000 bbl crude unit, to match its cracking capacity.

ESSO TO OPERATE GREASE PLANT. Large-scale operation of a continuous grease-making plant will be begun by Esso Standard Oil Company at its Baltimore refinery early in the fall of 1948, that company announces. The plant will be devoted to the manufacture of lime soap greases and the new process will revolutionize grease-making, company officials believe. It will permit continuous packaging of greases, whereas formerly packaging a batch of grease could not begin until the entire batch was completed. A method for cooking the soap rapidly now permits operators to accomplish in 45 min a job that did require 3½ hr.

DROPS SYNTHETIC UNIT PLANS. Decision to discontinue the preparations for building the synthetic fuels plant in the Hugoton Field, near Garden City, Kansas, has been announced by officials of Stanolind Oil and Gas Company. The tremendous increase in the costs of building the plant is given as the reason for the discontinuance, Stanolind president Bullard stated.

Originally the plant was scheduled to produce 6000-7000 bbl per day of synthetic fuels and byproducts, from 60,000,000 cu ft or more of natural gas, utilizing the American developments in process derived originally from the so-called Fischer-Tropsch synthesis. Another plant of this type is under construction at Brownsville, Texas, and Stanolind's part in connection with that plant, processing the oxygenated and other chemicals produced, will be continued.

ASHLAND TO REVAMP TCC UNIT. Contract for complete revamping of its Wartime-built Thermofor Catalytic Cracking unit has been let by Ashland Oil and Refining Company to Catalytic Construction Company, and the work is now under way, T. Ellwood Webster, president of Catalytic Construction Company, has announced. The unit is to be modernized completely, which includes converting it to a solid-bed design, with a new system for distribution of catalyst. Increased carbon-burning capacity will be obtained by adding two burning zones to the present eight.

REVISE SPECIFICATIONS. Revision of the Commercial Fuel Oil Specifications of the Bureau of Standards, whereby one grade is dropped and another introduced, has been announced by that bureau. These standards were last revised in 1940, and are designated as CS-12-40; the new revision is designated as CS-12-48.

No. 3 grade is omitted from the new specification. Instead a No. 4 is included, being somewhat more volatile than either No. 5 or No. 6; it is for use with burner installations having no means for preheating fuel oil, flash pf 130 F, pour point, 20 F. Maximum viscosity is 125 sec SUV, min is 45 sec SUV at 100 F. New No. 5 oil is a residual type fuel for use where preheat facilities are available, and with viscosity limits of 150 sec SUV min at 100 F, and 40 sec. Saybolt Furol at 122 F. Copies of the revised specifications may be obtained from Commercial Standards Section, U. S. Bureau of Standards, Washington, D. C.

TO BUILD 45,000-GAL PLANT. Construction of a natural gasoline plant to produce 45,000 gal per day of liquid products, including natural gasoline, propane and butane was begun late in August, for Cisco Hydrocarbons Company. The plant is connected with the pressure maintenance project of Fred. M. Manning Company in the O'Conner-Kimmel pool.

This plant will cost about $1,500,000, is designed, and will be built by Fish Engineering Corporation of Houston. It will process about 20,000,000 cu ft of gas per day. Ray C. Fish is president of Cisco Hydrocarbons, and E. Armstrong of Houston is vice president in charge of operations.

NEW WARREN GASOLINE PLANT. A new gasoline plant for processing gas from the Taylor Corner and West Fields will go into operation some time in September, according to B. W. Washburn, Warren Petroleum Corporation engineer, which company is building the plant.

COOKE COUNTY TO HAVE GASOLINE PLANT. Construction of a natural gasoline plant to process the gas from the Sivels Bend Field, Cooke County in North Texas, is announced by Stanolind Oil and Gas Company. Initial capacity of the plant is to be 2,500,000 cu ft of gas per day.

The first installation will be a compression plant to cost about $125,000, but the unit will eventually be converted to an absorption plant, the overall cost of which will be about $500,000, and will be designed to recover a large percentage of the propane and butane in the gases.

CARBON BLACK PLANT SOLD. Sale of the channel type carbon black plant, belonging to War Assets Administration to Cabot Carbon Company was announced recently, the sum being $773,500 according to the report. The plant was constructed during World War II by the U. S. Government, and is rated at 15,200,000 lb of black per year. Its original cost was $2,250,000 and it is the last of 6 large-capacity black plants to be disposed of by the government.

GULF BUILDING NEW MEXICO PLANT. Gulf Oil Corporation has started construction of a large natural gasoline plant in the Eunice Pool, New Mexico, the initial capacity to be 30,000,000 cu ft of gas per day. Later, it is understood, the plant will be expanded to handle 50,000,000 cu ft per day. The unit will produce natural gasoline and liquefied petroleum gases and will be completed in mid-1949.

THE Petroleum Engineer
SEPTEMBER, 1948

Distribution of Pumping Costs

By RICHARD SNEDDON, *Pacific Coast Editor*

THE need has long been recognized for some rational breakdown of well pumping costs that might give a reasonably reliable indication of cost distribution, and at the same time provide a means of comparing costs between like systems in divergent areas. Individuals and institutions have analyzed their own pumping operations and have segregated the total expense into well defined categories, but there has not hitherto been any effort to pool such findings in order to determine the average cost effect of the various incidentals included in the pumping process, for the complete range of conditions encountered in the industry. Open competition and free enterprise have made it necessary that costs in all departments of the petroleum business be held to an absolute minimum, and there is no good reason why pumping should escape the close scrutiny to which other cost items are subjected.

No matter how meticulously the production foreman may prepare the record of his own pumping costs, however, if he is at all sensitive to the basic need for accurate figures, he will be excited by two inevitable discoveries: (1) The wells with which he has been concerned will vary in pumping cost among themselves, even when apparently operated by the same methods and mechanisms, and (2) they will lack agreement on cost of pumping with wells in other areas. No production man can be quite comportable with discrepancies of this nature requiring explanation. He can fairly well take care of the first contingency by examining his own problem, making a change here and a change there, and then comparing today's cost with yesterday's. But when he attempts to compare his own well pumping costs with those of other operators, he finds either that no basic data on the subject are available, or that such information as is available is so differently acquired and disposed that it is not at all comparable with his own.

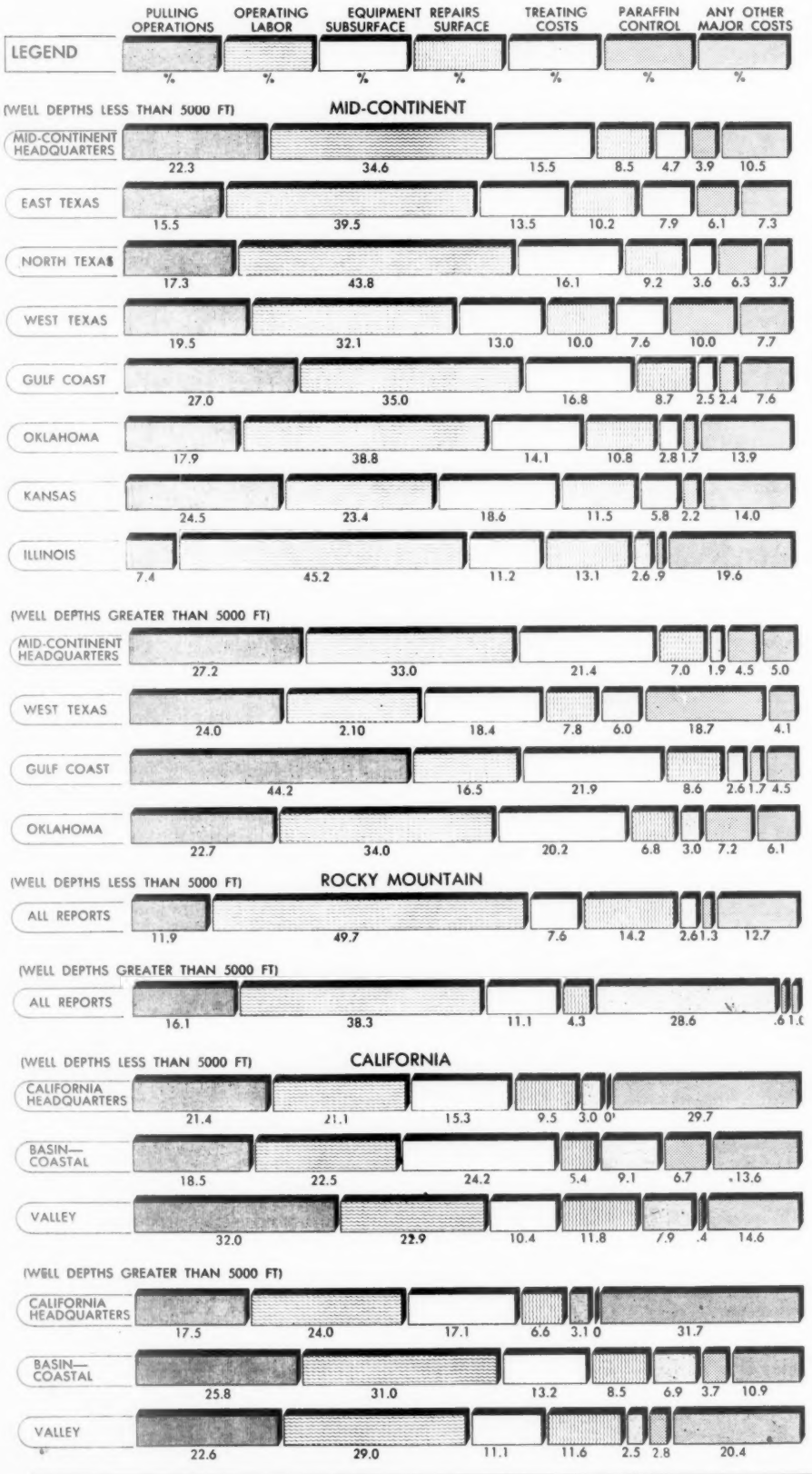
For the first time a national survey has been made to learn pumping costs in various areas. The survey gave some of the answers and brought up additional questions that require more data.

EXCLUSIVE

In order to remedy this situation insofar as possible, a survey was made recently by a nationally known equipment manufacturer to determine on a percentage basis how the petroleum industry's well pumping expense is distributed. It is now realized that this survey was inadequate in certain respects, but although it was the first of its type and scope ever attempted, it did develop results of sufficient interest to warrant a preliminary discussion here, and at the same time indicated rather clearly some adjustments that should be made in any future survey to assure the procurement of really comparable figures. The survey form consisted of a questionnaire that split the well pumping costs into seven separate categories, and asked the operator to state what percentage of his costs normally fall in each category.

Approximately 200 complete answers were received and these have been segregated with respect to (1) geographic location, (2) wells not exceeding 5000 ft in depth, and (3) wells more than 5000 ft deep. As intimated, it has become obvious that more complete data are necessary to a more effective survey. For instance, the number of wells covered by the cost given should have been supplied

The results of the survey made on pumping costs is summarized in these bar graphs. Approximately 200 complete answers were received from questionnaires, which were segregated with respect to: (1) Geographic location, (2) wells not exceeding 5000 ft in depth, and (3) wells more than 5000 ft deep. The section entitled "Mid-Continent Headquarters" consists of the unweighted averages and are placed so that they can be compared with the weighted averages from districts within the area.


PULLING OPERATIONS
OPERATING LABOR
EQUIPMENT REPAIRS SUBSURFACE
REPAIRS SURFACE
TREATING COSTS
PARAFFIN CONTROL
ANY OTHER MAJOR COSTS
LEGEND
%
(WELL DEPTHS LESS THAN 5000 FT) MID-CONTINENT
MID-CONTINENT HEADQUARTERS 22.3 34.6 15.5 8.5 4.7 3.9 10.5
EAST TEXAS 15.5 39.5 13.5 10.2 7.9 6.1 7.3
NORTH TEXAS 17.3 43.8 16.1 9.2 3.6 6.3 3.7
WEST TEXAS 19.5 32.1 13.0 10.0 7.6 10.0 7.7
GULF COAST 27.0 35.0 16.8 8.7 2.5 2.4 7.6
OKLAHOMA 17.9 38.8 14.1 10.8 2.8 1.7 13.9
KANSAS 24.5 23.4 18.6 11.5 5.8 2.2 14.0
ILLINOIS 7.4 45.2 11.2 13.1 2.6 .9 19.6
(WELL DEPTHS GREATER THAN 5000 FT)
MID-CONTINENT HEADQUARTERS 27.2 33.0 21.4 7.0 1.9 4.5 5.0
WEST TEXAS 24.0 2.10 18.4 7.8 6.0 18.7 4.1
GULF COAST 44.2 16.5 21.9 8.6 2.6 1.7 4.5
OKLAHOMA 22.7 34.0 20.2 6.8 3.0 7.2 6.1
(WELL DEPTHS LESS THAN 5000 FT) ROCKY MOUNTAIN
ALL REPORTS 11.9 49.7 7.6 14.2 2.6 1.3 12.7
(WELL DEPTHS GREATER THAN 5000 FT)
ALL REPORTS 16.1 38.3 11.1 4.3 28.6 .6 1.0
(WELL DEPTHS LESS THAN 5000 FT) CALIFORNIA
CALIFORNIA HEADQUARTERS 21.4 21.1 15.3 9.5 3.0 0 29.7
BASIN—COASTAL 18.5 22.5 24.2 5.4 9.1 6.7 13.6
VALLEY 32.0 22.9 10.4 11.8 7.9 .4 14.6
(WELL DEPTHS GREATER THAN 5000 FT)
CALIFORNIA HEADQUARTERS 17.5 24.0 17.1 6.6 3.1 0 31.7
BASIN—COASTAL 25.8 31.0 13.2 8.5 6.9 3.7 10.9
VALLEY 22.6 29.0 11.1 11.6 2.5 2.8 20.4

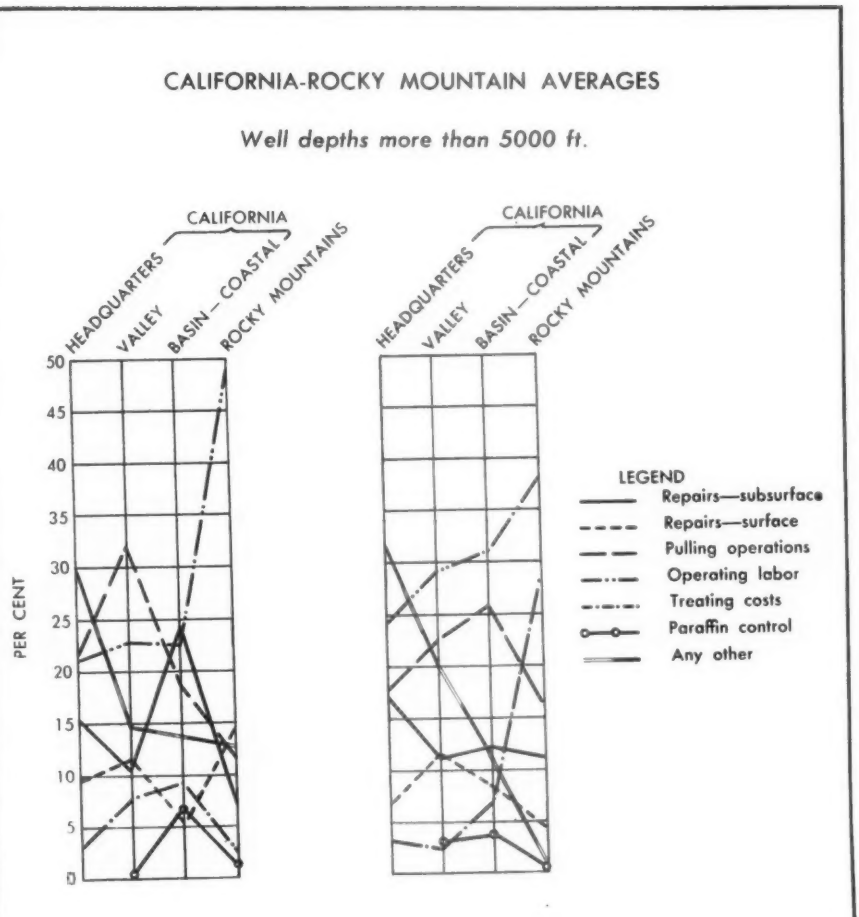
in each case, in order to permit proper weighting of the results, and, of course, there is need for a clarification of some of the items. Pulling operations in some reports include part of the labor cost, which is all right so long as the fact is known and proper segregation of the items can be made in the final summation, or so long as pulling and labor costs are lumped as a single item in the last analysis.

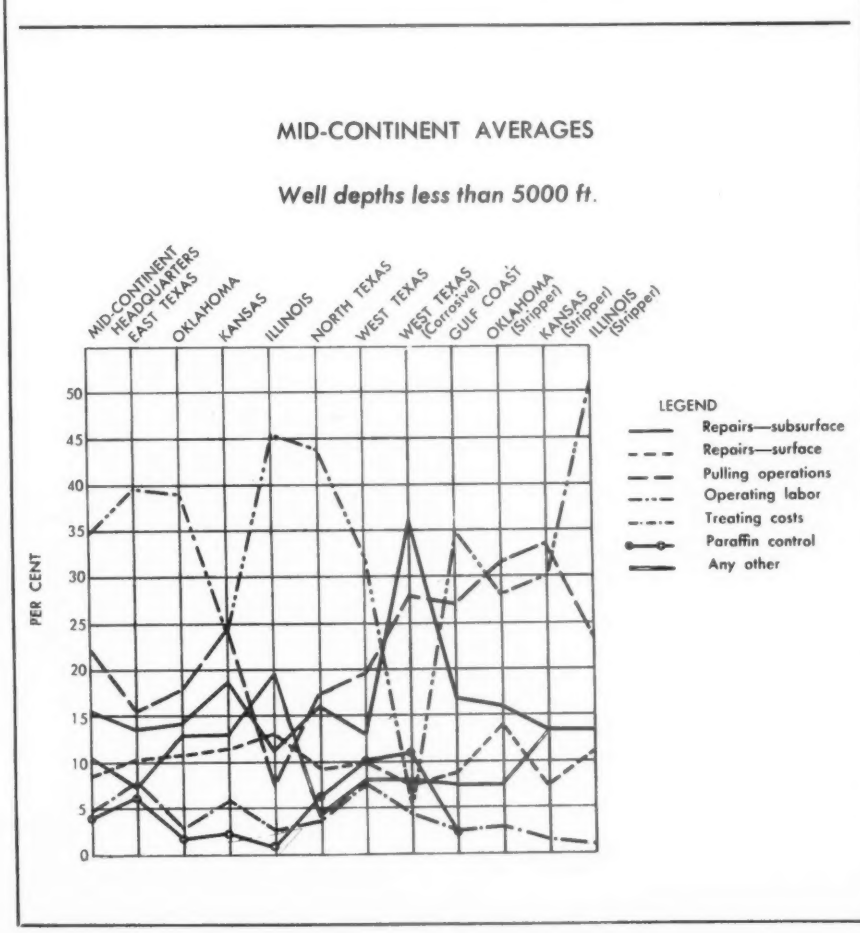
The questionnaire answers were averaged for the three distinctive groups already mentioned, and the results are to be found in the following tabulation:

	General average, per cent	Wells under 5000 ft, per cent	Wells over 5000 ft, per cent
Repairs—subsurface equipment	16.74	14.72	20.21
Repairs—surface equipment	8.80	9.35	7.85
Pulling operations	22.29	19.82	26.53
Operating labor	31.04	30.73	31.55
Treating costs	4.03	4.51	3.23
Paraffin control	3.75	3.15	4.75
Any other	13.35	17.72	5.88
Total	100.00	100.00	100.00

Although the questionnaires were directed to operating personnel, superintendents, engineers, and those qualified by experience or otherwise to make a logical segregation of pumping costs, it was recognized in the beginning that the answers received would vary in significance or importance in the final evaluation. In the first place, results reported would of necessity cover every type of pumping project from a single stripper well to a large district field program as carried on by a major producing company, and unit costs would vary accordingly. Besides being influenced by the extent of operations in each individual case and by the number of pumping units involved, the breakdown as submitted would naturally be affected by the method of original compilation, or the accounting system employed. In considering the returns, however, it was frequently possible to evaluate the comparative quality and weight of the answers by a knowledge of the extent of the company operations in the area, and by the obvious effort that was exerted to arrive at accurate figures.

It is evident that some contributors spent considerable time not only in the accumulation of pertinent data, but in the apportioning of costs whereas others had no access to actual records, and submitted the best estimates they could make from experience and such information as they had at their disposal. On the basis of these and other factors, the replies were weighted arbitrarily to bring them as





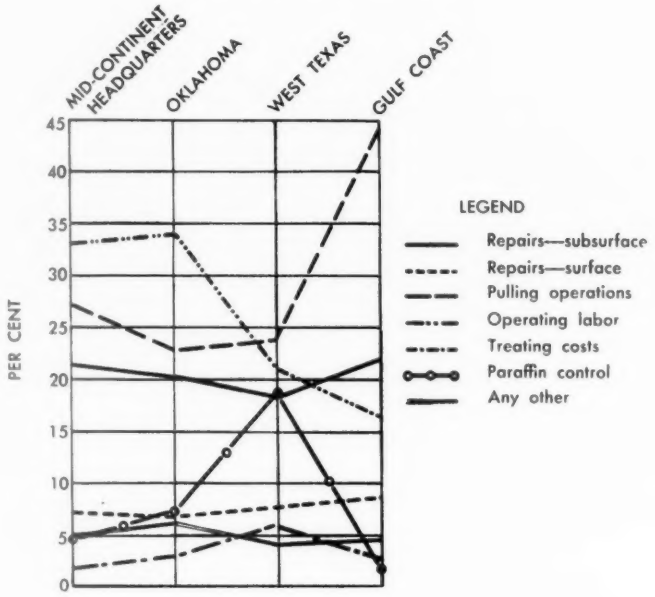
nearly as possible into comparable relationship; and in order to provide some index of the accuracy of such weighting, the replies received from area headquarters were averaged as submitted and without adjustment. It is assumed, of course, that these particular reports would be based on actual figures covering large scale operations and would thus be of the highest accuracy. An examination of the tabulation of averages shows that the weighting system was equitably applied, otherwise costs on the various items would not be in such close agreement. In the bar graphs, incidentally, the section entitled "Mid-Continent Headquarters" consists of the unweighted averages, which are placed so that they can be compared with the weighted averages used in the graphs from districts within the area.

It is to be noted that whereas the percentage pulling and labor costs vary quite widely within the categories as shown in the accompanying chart, the sum of the two is remarkably uniform. These two items together appear to account for about 50 per cent of the total pump operating cost. The fluctuation in individual items is rather easy to understand. It is almost certainly due to the difficulty of completely segregating pulling and labor costs, because to a large extent they are the same thing. Indeed, it is not at all unlikely that in some organizations all labor costs attributable to well pumping operations are lumped together, and for such purposes as this survey are later arbitrarily segregated according to the best judgment of the production accountant. They can, of course, be separately accumulated on the basis of time cards, and it is assumed that in the main the results here were so acquired.

Examining the surface and subsurface repair costs, which run approximately 25 per cent of the total, we find that there seems to be a general inclination to segregate these two items separately, although it is possible that in some instances they are accumulated together as "equipment repair costs," and later arbitrarily divided. In any case it is to be remarked that the curves only show what might be termed "wild" fluctuations when as in West Texas corrosive conditions exist in the wells that send sub-surface repair costs high above the average level, or some other local condition affects one aspect of the pumping process in an abnormal degree. The other cost items—treating and paraffin control—are relatively small but are nonetheless important. The rather close agreement between the figures in like categories as shown in the table of averages, indicates that the errors

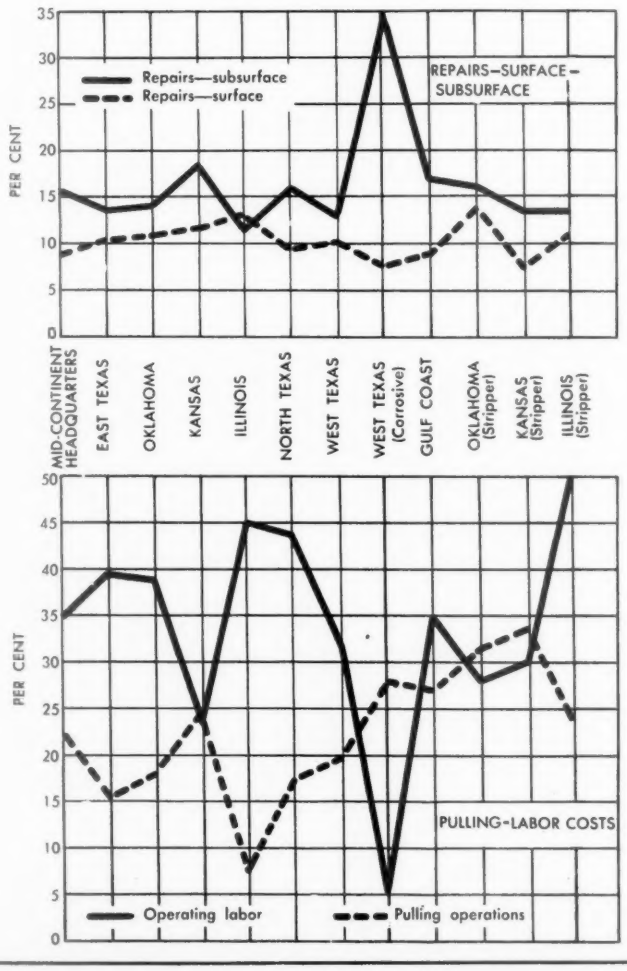
MID-CONTINENT AVERAGES

Well depths more than 5000 ft.



REPAIRS, PULLING, AND LABOR COSTS

All for well depths less than 5000 ft.



are not in one single direction, but are plus and minus, and tend to cancel each other out. The general agreement also indicates that the fundamental bases of arriving at the various cost items are reasonably similar for all areas and districts.

As previously mentioned, it is now apparent that the questions as propounded could with distinct advantage have been clarified somewhat, and that one or two additional questions would definitely have enhanced the value of the survey. In general, the ultimate weighting of results could have been more logically contrived had the questionnaire asked specifically, "How many wells does this report cover?" "Are the figures reported here derived from actual cost records, or are they estimates?" "Is the segregation of surface and sub-surface repair costs made by apportioning the total repair cost, or are the two items actually compiled separately?" Then again, some of the questions that were asked could well have been more pointed. The one relating to labor, for example, might better have been worded to exclude the cost of well pulling labor, which is in reality a part of the well pulling cost. Finally, the "any other" item of cost is sufficiently high to warrant a still further breakdown.

Despite omissions, however, and the inadequacies of a few of the questions, the survey as can be seen was productive of some very interesting information. That there is need for such information there can be no question. This is evident not only in the large number of completed questionnaires that were returned but in the pains that many contributors took to amplify them with other relevant data and explanatory matter. The entire subject is one that appears to be intensely interesting to production superintendents and foremen, and that is as it should be. After all, a large part of the cost of pumping is incurred during shut-down time, so that it might also be proper to include loss of production as an item of cost. Certainly there can be no rational argument against an orderly effort to analyze all the factors and to determine wherein savings might be brought about. The data acquired in this survey are hence set forth here, not with the idea of bringing the last word on the subject, but rather as a provocative gesture that might stimulate further concerted study of well pumping costs. Meantime, they probably constitute the only available information of the type and should be valuable to the production man if only to give him some norm from which to measure the efficacy of his own operations.

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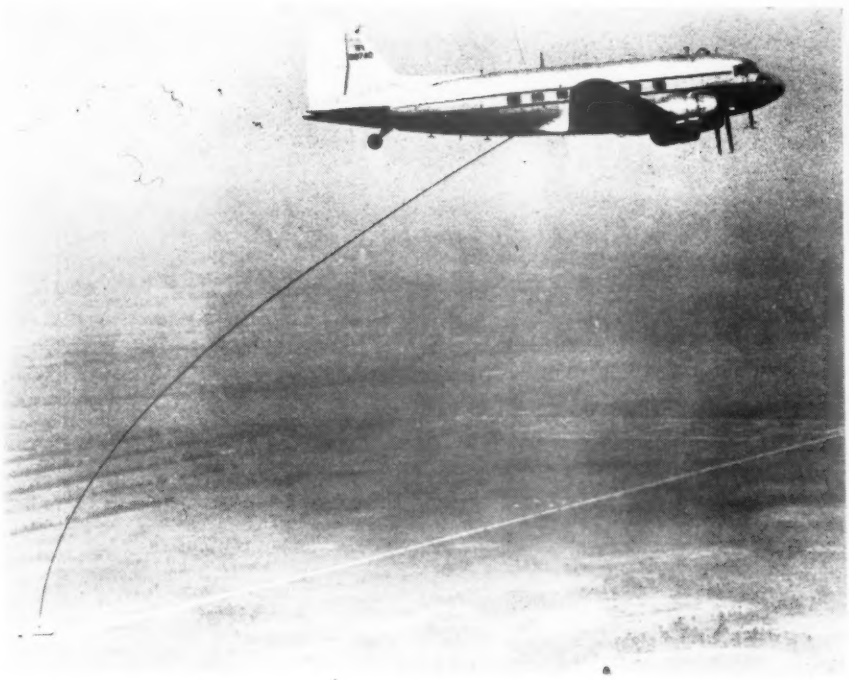


FIG. 1. A flying magnetometer is shown trailing beneath a flying laboratory of Gulf Oil Corporation at about 1500 ft altitude and 150 miles per hour. This device permits magnetic mapping of heretofore inaccessible areas, such as jungle, oceans, and mountains.

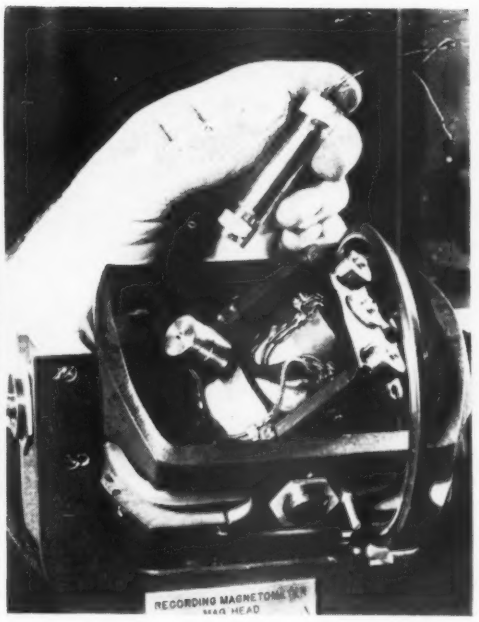


FIG. 2. The tube-like piece being held is the heart of the air-borne magnetometer. It contains a supersensitive strip of metal that measures 1/50,000th part of the earth's magnetic field.

Flying Magnetometer Speeds Oil Search

FIG. 3. The flying magnetometer is given a final functional check and adjustment in the Gulf Research Laboratories at Harmarville, Pennsylvania, before it is sent to be installed in the airplane. Final adjustment must be made in the field, away from conflicting magnetic influences of such things as tall steel buildings, high tension lines and power plants. The magnetometer's success is due in large part to its ability automatically to orient itself at all times so that it is in perfect alignment with the earth's magnetic field. Magnetic variations of significance are those caused by differences in composition and proximity to the surface of the magnetic igneous rocks. When the structural configuration of these basement rocks is such as to bring them relatively close to the surface a magnetically high area will be indicated. Gulf officials say that the magnetometer has put them years ahead of where they would be otherwise in their search for oil.

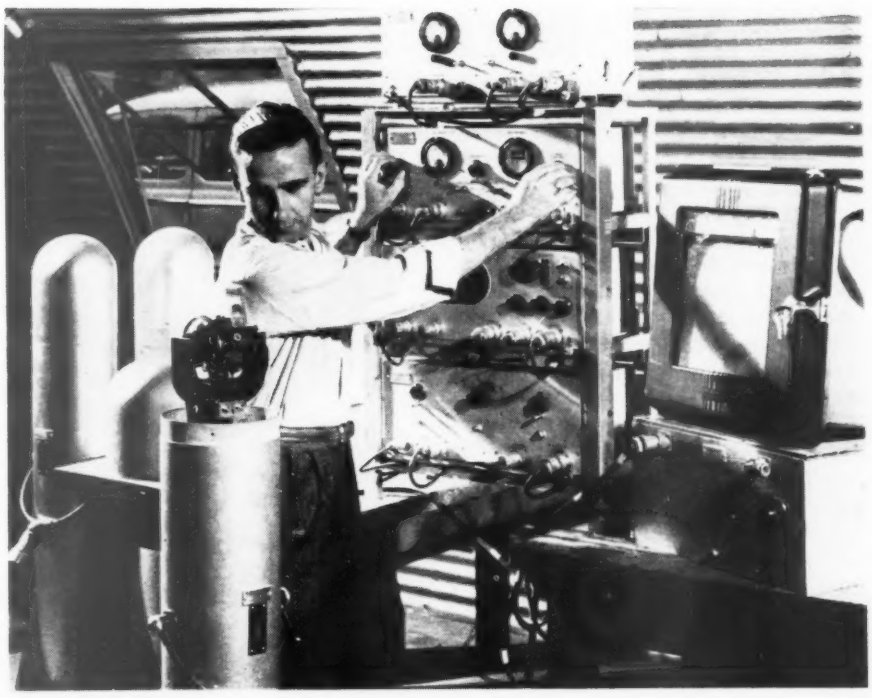


FIG. 4. The "bird," as the air-borne magnetometer is called, is lowered by a special hoist from a cradle in the cabin of the DC-3 that Gulf has converted into a flying laboratory. The information is transmitted to electronic instruments in the airplane that record it on a graph in a series of continuous measurements. Housed in a bomblike structure, the magnetometer trails from the airplane on a 65-ft cable, made up of 12 separately-shielded conductors surrounding a ¼-in. flexible aluminum conduit. So sensitive is this device that it measures a change of 1 gamma in the earth's magnetic field, which is roughly 50,000 gammas. Its magnetic sensitivity makes it ideal also for discovering the presence of other underground mineral resources. The Gulf airborne magnetometer has already completed surveys of thousands of sq. miles of rugged country in eastern and western Canada and 85,000 sq. miles of ocean area in and around the Bahamas, as well as parts of New Mexico, West Texas, and the South American jungles.

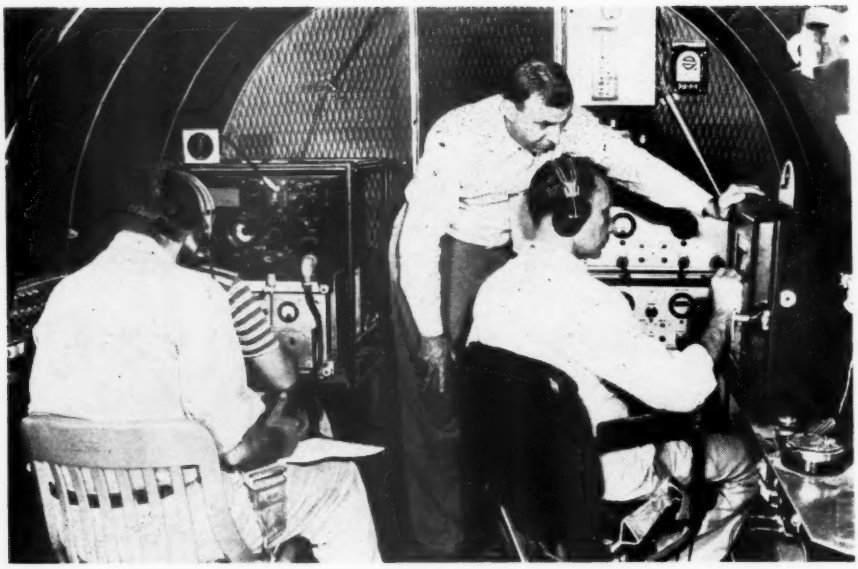
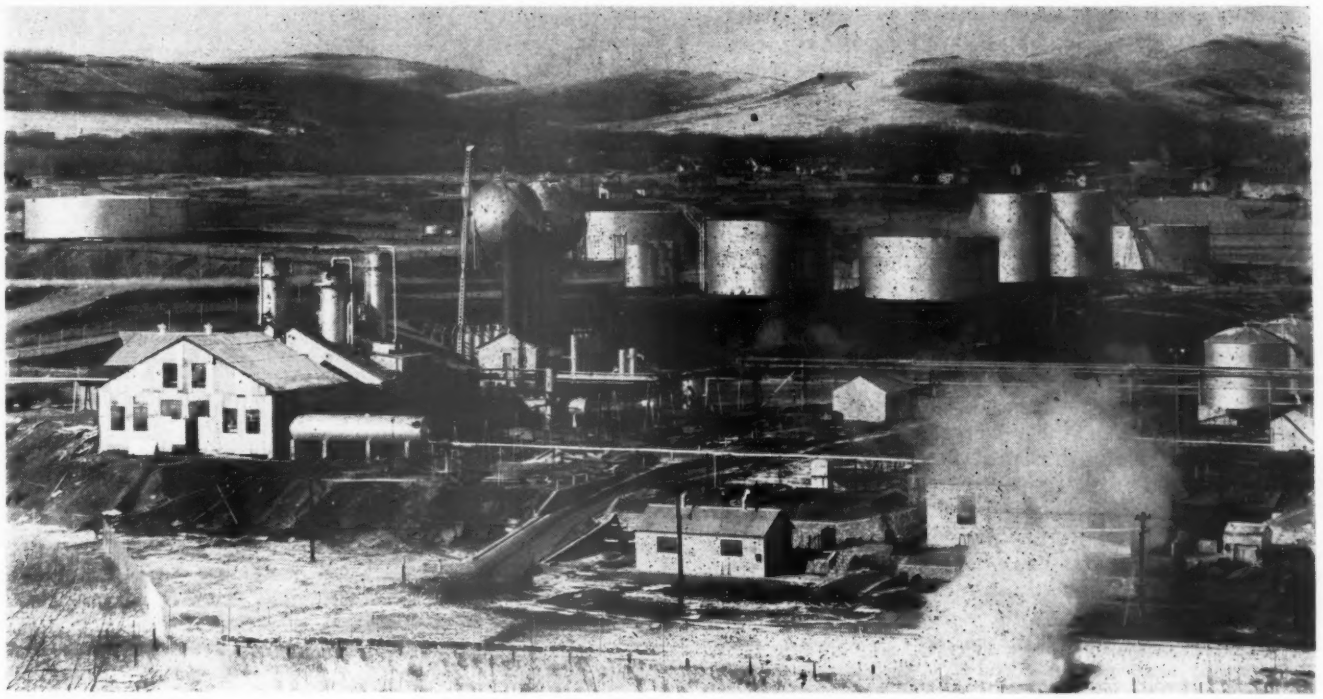


FIG. 5. The flight crew of the magnetometer party keeps busy while aerial magnetic surveys are under way. The Shoran (short range navigation) operator in the striped shirt keeps his radar-like device in tune with two Shoran ground station units so that the plane can follow accurately the predetermined line of flight. On the right the magnetometer operator is shown making notations on the magnetic record. The crew usually flies about five hours daily, mapping in areas 75 miles long and about a mile apart, some 700 square miles a day. The information the magnetometer reveals permits the geophysicists to "high-grade" a state, region, or area, selecting for further study those sections that seem to possess oil possibilities.

FIG. 6. Girl workers in the Gulf geophysics laboratory are at the plotting table to fix accurately on a map the location of the magnetic readings taken on the plane in flight. In another section mathematical calculations are made as a prelude to the preparations of maps of basement rock formations thousands of feet beneath the earth's surface. When the survey is completed, the geophysicist studies the magnetic contour map and renders his verdict. Technical advice of this kind has reduced the odds against wildcat wells from about sixteen to one to five to one. It is now the fastest known means for procuring geophysical prospecting data of any kind and compares favorably in cost with other methods.

* * *



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Absorption plant of Madison Natural Gas Company.

Natural Gas Price in Turner Valley

By FLOYD K. BEACH*

SINCE August 15, 1948, producers of natural gas in Turner Valley have been receiving 4.75 cents per M cu ft at the wellhead for their share of gas delivered to market, and Canadian Western Natural Gas Company, Ltd., is paying 10.75 cents at the gate where its supply is picked up from Madison Natural Gas Company, Ltd. The former prices, effective since January 1, 1947, were 3 cents at the wellhead and 9 cents at the gate. Both schedules of prices just mentioned were set by The Natural Gas Utilities Board and the basis for arriving at the decision that came into effect January 1, 1947, is likely to become a precedent in rate cases, not for the actual prices resulting but for the manner of reaching them. That decision was a voluminous affair running to about 200 pages mimeographed and containing numerous schedules of figures detailing the computation of various valuations. Because it goes into such detail, the decision has not been reviewed as carefully as its importance merits, and we here attempt to place the salient features before the industry.

The decision was not a court judgment. Courts are circumscribed by such rigid rules of evidence as to make the problem of hearing opinions impossible, yet a fair decision in so complicated a matter as a rate hearing can only be reached after hearing opinions of interested parties. The sequence of events leading to the decision was briefly as follows:

▸ **Early gas shortage.** Canadian Western had in 1912 laid a 16-in. line some 175 miles from Bow Island field to supply Lethbridge and Calgary, cities which at that time had populations of about 9,000 and 45,000, respectively, and the towns along the route also were connected. By 1920 the field was nearly exhausted. Its possibilities had been developed until the boundaries had been outlined and edge water had risen. Consumers could still operate cook stoves in summer, but the yield was inadequate for space heating in cold weather. Efforts to find other supplies adjacent to the pipe line developed a small field at Barnwell but the pressure and open flow were so small that its gas failed to help the situation noticeably. That discovery was in 1918. In Turner Valley a small flow of gas from three wells of Calgary Petroleum Products was processed in an absorption plant for recovery of natural gasoline and the gas was being flared. A fire destroyed the plant in 1920 and precipitated reorganization of the company. Imperial Oil, Ltd., put in some capital and the organization became Royalite Oil Company and a new plant was built. In 1921 Canadian Western laid a combination 6-in. and 8-in. line about 15 miles from the new plant to

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EXCLUSIVE

feed the main transmission line at Okotoks, but again the supply failed to meet the potential demand. A field was found at Foremost and was connected in 1923 by 30 miles of 10-in. line to the main transmission line near Bow Island. Also in 1923 Royalite began drilling a fourth well and found a flow of about 7,000,000 cu ft a day in a Cretaceous sand. This flow was sweet and was turned into the line to Okotoks and thence into the system. It tided the situation over the winter, but the flow fell off and deeper drilling was undertaken in 1924. In October a large gas flow was found in the Rundle (Upper Madison) lime, but the well caught fire. After some weeks the fire was extinguished and the well was controlled, although its condition was such that it could not be closed in, nor did the company dare put pressures of much more than 500 psi on the flow. The flow was passed through a separator, giving yields of 500 to 600 bbl a day of "naphtha" or condensate and some 20,000,000 to 24,000,000 cut ft of sour gas.

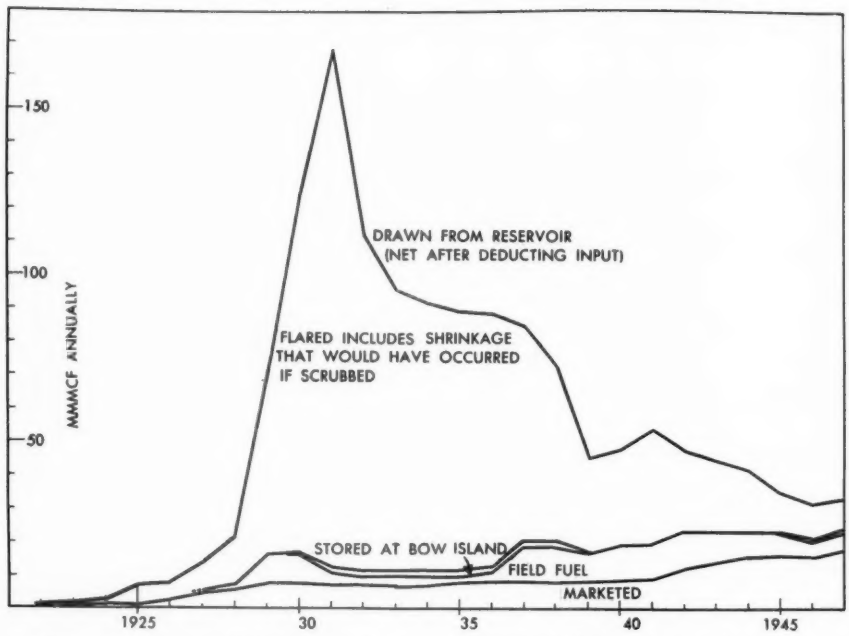

FIG. 1. Gas production from Turner Valley and disposal. Yearly totals.

Exclusive contract. The sour gas was not acceptable to customers in its natural state, but if the sulphur could be removed the one well would more than supply the summer demand and would greatly ease the winter situation, and there was every hope that additional wells would be completed and that their gas production would be adequate to meet the entire demand of the system. Royalite therefore offered to build a scrubbing plant but they wanted an exclusive contract with Canadian Western in order to protect the rather large expenditure. The exclusive contract was made and not only were the parties to the contract happy about it, but the public dependent on fuel gave a combined sigh of relief when a dependable source of space heating became available. The contract provided for payment of 7¾ cents per M cu ft for the scrubbed gas at the gate, and in designing transmission lines an intake pressure of 300 psi at the gate in times of peak load was based on conditions of the contract. Canadian Western laid a 10-in. line some 30 miles to Calgary and later a 14-in. line nearly 18 miles to join the 16-in. main at De Winton.

Flaring of gas follows. Completion of a well yielding 500 bbl or more a day of oil that could almost be used in a motor car without refining, was a signal for great drilling activity. Few wells in the immediate vicinity got large enough yields to pay out drilling costs from naphtha alone. They needed a gas market to make them pay.

Royalite was soon able to supply the gas market from its own wells, and the surplus gas was flared. Well owners were not sure that they dared close in their wells after the experience with Royalite No. 4, so whether the well paid or not it was produced. Eventually it was demonstrated that pressures in the reservoir could be met by the existing equipment, but most operators continued to produce and flare the gas so long as they could meet operating expense, and long after there was any hope for shareholders to recoup their investment.

No unitization agreement. As early as 1928 and 1929 efforts were made to save the gas but division of authority between federal and provincial authorities hampered government action. Canadian Western made a gesture by storing some of the surplus in the depleted Bow Island field beginning in 1930 and on October 1 of the same year the dominion government handed over to the province of Alberta the natural resources administration. Alberta took early measures to try to stop the waste, setting up a Conservation Board. The Board had powers only to study the situation and report back, and its 1931 operations were concurrent with the peak of flaring, which aggregated more than 150,000,000,000 (billion) cu ft that year. The Board's report recommended unitization of the field on a voluntary basis, but failure to obtain unanimous consent brought failure of the unitization plan. Some measure of control came through restricting each well to a percentage of its open flow, but there was only moderate improvement in the situation.

Absorption plants built. As reservoir pressures declined, the efficiency of separators declined. Charcoal tests of gas leaving the separators indicated that more liquids passed the separator than were caught. In 1933 Royalite built its first absorption plant to process gas collected from its own wells and from subsidiary companies. Recovery was highly successful from the start, and gas from the absorption plant went on to the scrubbing plant for delivery to the market, with excess above market requirements flared before delivery to the scrubbing plant.

In 1934 Gas and Oil Products put in an absorption plant to process gas from wells they controlled and from some neighboring wells. In 1935 Royalite built a second plant, also processing gas from some independent producers. In 1936 British American Oil Company, Ltd., built a plant and gathered gas from independent producers in its locality. In the course of all this development agreements with independent producers by the three operators of plants led to some duplication of effort, and gathering lines for one plant sometimes crossed gathering lines for another plant.

Only the first Royalite plant could deliver gas to the market and residue gas from the other three plants was flared.

Voluntary cut in flaring. In 1936 Turner Valley Royalities well on the west flank of the southern part of the field found liquid crude oil and with it only enough gas to lift the oil to the surface. In a short time this well and others similarly located paid out drilling cost and began making a profit. Operators took stock of the situation and realized that unrestricted produc-

tion from the gas cap must affect the crude oil reservoir adversely. In 1938 the Petroleum and Natural Gas Conservation Board was set up, and early in 1939 gas-cap production was limited to market requirements over most of the gas-cap. Absorption plants extended their gathering lines to pick up much of the gas coming from crude oil wells. However, the anomaly arose of the need to draw gas from the gas-cap for market when at the same time gas was being flared from three plants and from other crude oil wells whose residue gas was not being collected.

▸ **Natural Gas Utilities Act.** Surveys of remaining gas reserves indicated that at the existing depletion rates, Calgary would soon lose Turner Valley as its source of supply. If all the gas being flared, or a reasonably large proportion of it could be made available for the market and if the production from crude oil wells in excess of summer market requirements could be stored, there was gas available for the distribution system to carry the load until about 1963. Possibly at some time before that, the supply might need to be augmented for part of the year, and for some time after there would still be gas enough for summer load.

Action to save gas was urgently needed but the voluntary expenditure of money needed to construct the works was still hampered by the exclusive contract and by questions arising out of Public Utilities Board operations that might adversely affect amortization of capital.

In 1944 the Alberta Legislature therefore passed a statute that cleared the way for action. It set up The Natural Gas Utilities Board and empowered it to order the proprietor of pipe lines or scrubbing plants to construct or rearrange pipe lines; to install compressor stations and equipment necessary for conserving and handling gas for delivery; to direct that gas be gathered and transported when it can effectively and economically be used or stored; to purify, to purchase, and to return to the ground gas produced in excess of market requirements, and to sell to wholesalers and retailers in quantities and at prices fixed by the Board. The Board may require owners to produce in the required quantities or may restrict or discontinue production, or may permit any well to be used as an input well. All these powers are subject to such compensation as the Board may prescribe. Powers are also given to the Board to fix the *just and reasonable* price at various points in the system up to the delivery of gas to a wholesale purchaser or to storage. The power to regulate retail price of gas was already the prerogative of The Public Utilities Board of Alberta.

The statute thus wiped out the exclusive contract by which Royalite Oil Company could supply the market and it also removed the uncertainty with regard to amortizing new works needed to save the remaining gas.

▸ **Board appointed.** The Alberta Government appointed G. M. Blackstock, K.C., who is also head of the Public Utilities Board, and Dr. E. H. Boomer, who was head of the Department of Chemical Engineering at the University of Alberta and chairman of the Petroleum and Natural Gas Conservation Board.

▸ **Board acts.** After a brief preliminary hearing the Board promptly ordered the installation of certain compressors and the laying of certain pipe lines needed to put low pressure gas into two of the absorption plants and compressors to put residue gas from all absorption plants into the scrubbing plant or into input wells. They put a resident engineer on the job during the execution of these orders to observe both the physical operations and the accounting problems. The required works had previously been designed by Thomas R. Weymouth, whose services had been retained in 1943 by the Conservation Board, so there was a minimum of delay in starting work, and by the end of 1944 the projected job had been completed.

▸ **Rate hearing.** To deal with the more complicated problem of fixing the just and reasonable price to be paid producers for what had previously been a by-product having no value after it had served as a source of energy to bring oil to the surface, and to distribute the cost of works undertaken through Board order as well as of works previously built, a hearing followed. At this hearing all interested parties could present their views in detail. Witnesses were under oath, but were free to present opinions and estimates, graphic representations of the effect of various courses of action, and in fact any pertinent observations. Quite an array of legal counsel attended and they could question witnesses if they wished, or merely hold a watching brief. Technical experts ranged from engineers to accountants and they gave evidence over a wide gamut of subjects. Company accounting systems and entries were laid open for scrutiny. All evidence in words was recorded by court reporters and each day's proceedings was mimeographed and available to counsel on the following morning.

The subject matter was varied. In order to attain some logical sequence of presentation an agenda was set up and each item exhausted, so far as possible, without allowing diffusion of attention to other subjects on the

British-American absorption plant.

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agenda. It started with evidence respecting remaining reserves of gas in the field and the portions available to the various gas gathering systems. Other subjects included throughput of various parts of the works, probable future throughput with and without the works built for conservation, other sources of gas in Alberta, consumer rates, alternative source of fuel and its relative cost, market sharing and pooling arrangements, rate bases for the companies involved, rate of return on rate bases, method of computing depreciation, cost of various stages in the operation, price that should be paid producers for their share in the market and price for their share in any gas stored.

The hearing began on March 12, 1945, and continued intermittently to June 21, 1946, actually sitting on 75 days. Dr. Boomer died suddenly before the decision could be written, leaving Mr. Blackstock with the burden on his shoulders. He brought down an interim decision at the close of 1946 and prepared a draft of the final decision, which was circulated among the principals prior to release of the full text. The final decision bore date of March 24, 1947, and it contained reference to any objections raised after circulation of the interim decision.

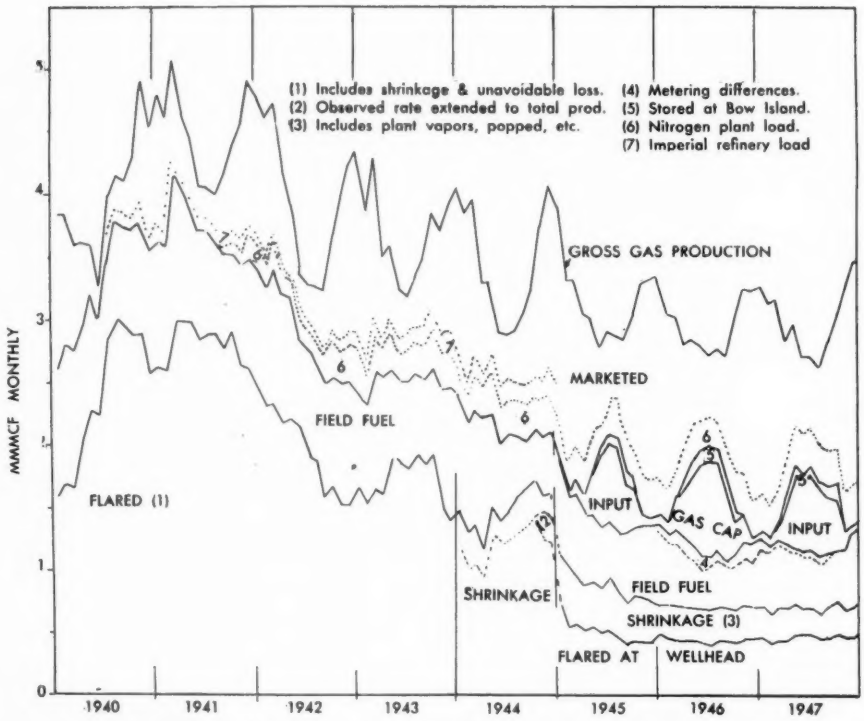

FIG. 2. Gas production and disposal from Turner Valley by months.

▸ **Works carried out under Board orders.** Royalite Oil Company set up a completely owned subsidiary under the name of Madison Natural Gas Company. It had two absorption plants, the first of which could deliver its residue gas to its scrubbing plant and thence to the market. The other plant had to flare its residue gas. This latter plant was scrapped. Some of the machinery was moved and re-erected at No. 1 plant. A pipe line was laid from the site of No. 2 plant to No. 1 and a compressor plant (No. 3) was erected to make transmission and entry to No. 1 plant possible. Added compressor capacity was installed at No. 1, and sundry changes made in the plant, and added gathering lines were laid.

Gas and Oil Products set up a subsidiary for gas operations under the name Gas and Oil Refineries. Its absorption plant operated at about 75 psi and early studies led to a decision involving little cost to G.O.R. A residue line was laid to pick up available residue gas, compress it in Madison No. 3 compressor plant, and put the compressed gas into Madison transmission line.

British American Oil Company set up a subsidiary for gas operations under the name B. A. Utilties. Its plant operated at a pressure requiring 150 psi at the well and could not pick up gas when wellhead pressures were below that pressure. Before any order was issued by the Board, British

Scrubbing plant of Madison Natural Gas Company.

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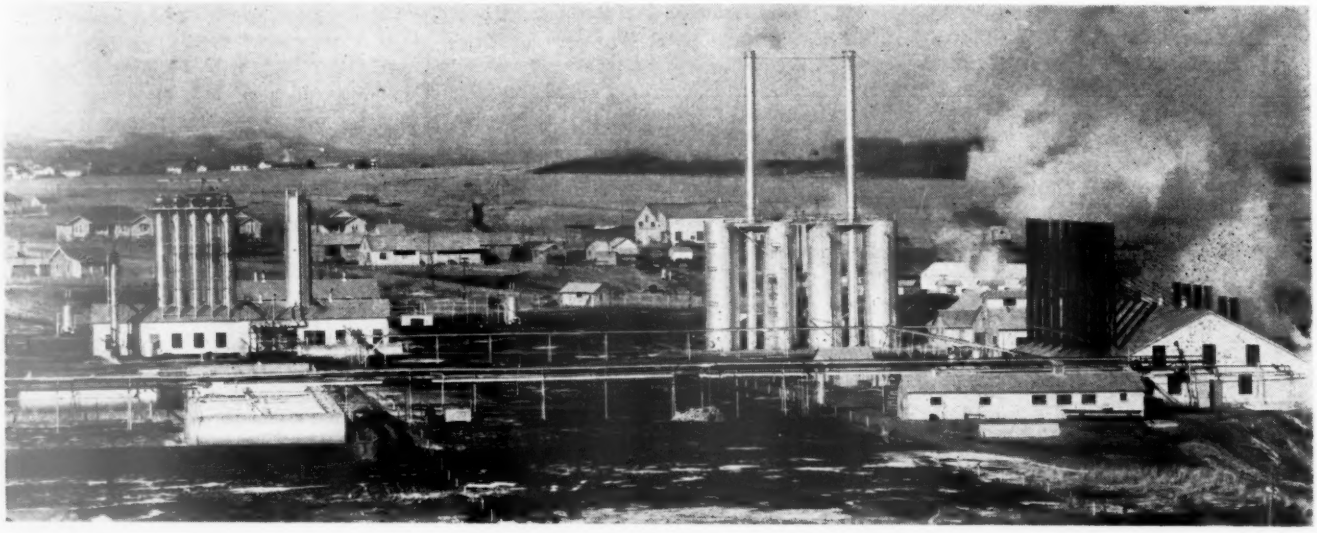


American applied, outlining a scheme it wished to carry out to get low pressure gas, compress it to a point where it would enter the plant, and after stripping natural gasoline to put the residue through another compressor, and lay a line to Madison scrubbing plant for delivery of its market share, putting any surplus into input wells for maintenance of reservoir pressure in the B.A. area. After outlining the scheme, B.A. offered to carry out the works at its own risk if given permission. The cost of the new works was estimated at a trifle under $481,000. The Board granted permission and the works were constructed, the costs running considerably above the original estimate. Some of the added cost was due to wartime shortage of labor, which could be evaluated from one particular contract, and some could be charged to extensions not contemplated in the original proposal.

▸ **Decision.** After 176 pages in which principles used and the arguments on which they are based were discussed, 28 pages of schedules follow. We shall touch on a few of the figures and the reasons given in the text for their adoption.

▸ **Madison cost allocation.** Madison's estimated cost of operation for the four years 1945-1948 was placed at $3,234,775 and was made up of direct operating costs, administrative and general costs, direct depreciation, and return on investment. The first two of these items were based on current experience, but the depreciation and return on investment were calculated by the Board's auditors along lines given step by step in the schedules.

Having estimated the four-year costs it was necessary to fix the proportion of them to be charged to various parties to be benefited. The division was more or less arbitrary after considering the evidence but as made, it charged:

Residue market	$2,624,867
Absorption plant	599,855
Producers of gas	10,053
Total	$3,234,775

In other words, the producers who benefit by having a market found for their by-product will contribute something. The absorption plant, benefiting by use of some of the equipment will find about 18½ per cent of the cost, while the residue market finds the bulk of the cost.

The costs were distributed under the following headings:

Scrubbing	$1,123,143
Gathering	1,499,639
Residue transmission	270,851
Repressuring	186,553
Rate hearing (proportion)	154,589
Total	$3,234,775

▸ **Rate base.** To find the rate base from which to work out direct depreciation and return on the investment, the Board adopted "historic cost" after canvassing "original cost," "prudent investment," and "reproduction cost." Historic cost differs from original cost only if the reviewer is not satisfied with the accounting and finds that operation costs had been charged to capital or vice versa. The Board held that there had been prudent investment if the physical property is still functional. Reproduction cost was held to be an uncertain figure involving market conditions for materials and labor at different times. Obsolescence enters, and one is faced with the questions, "Would certain machines be used if we were building new?" "Would this size of pipe be relaid?" "What would be the effect on market price of materials under present conditions if orders for the entire requirements were to be placed now?" These uncertainties and others caused rejection of any consideration of valuing most of the plant on "reproduction cost new."

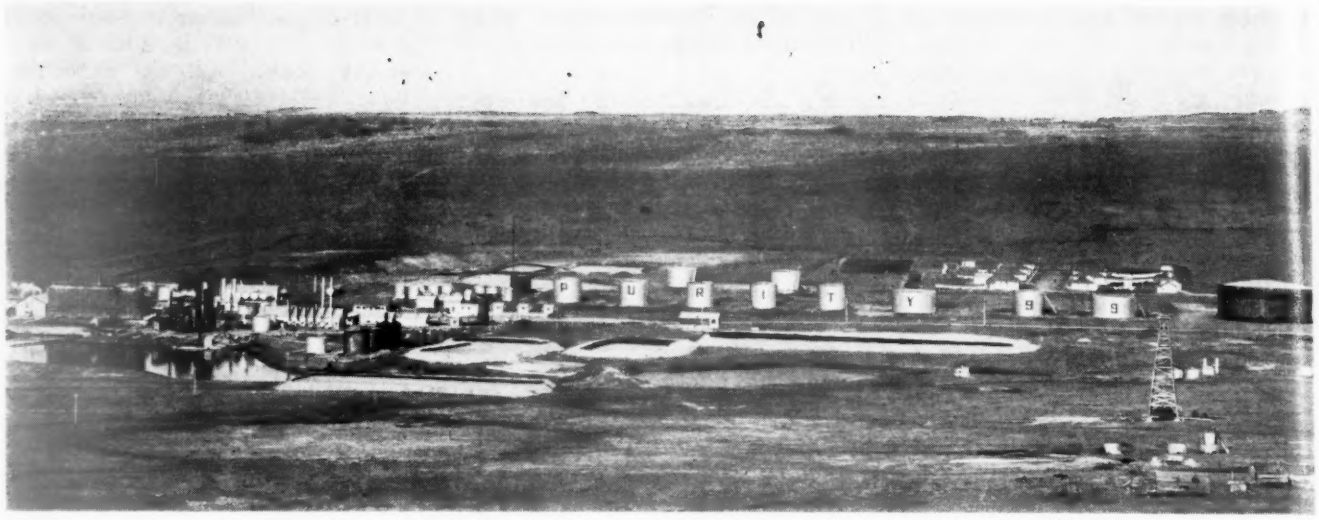
▸ **Depreciation.** With historic cost accepted, actual valid expenditures as shown by company records were tabulated by year of construction and depreciated to the year of valuation. Manner of depreciation was carefully considered, each group of equipment being given its basis.

The scrubbing plant was depreciated on the basis of throughput. It was estimated that after the end of 1943 the plant would scrub 358,558,000 cu ft. A table was prepared that worked back from that figure using actual past throughput by years to the first gas scrubbed. The table then said that assets acquired in 1926 would be depreciated 29.981268 per cent to the end of 1943. It went on by years so that assets acquired in 1943 were depreciated 1.983810 per cent by the end of 1943. The table was then applied to assets of the plant acquired in various years.

For depreciation of gas gathering lines a different gas reserve was necessary for the reason that others than Madison gather part of the gas, and gas gathered in past years was not all scrubbed. Hence a table of depreciation for gas gathering lines was prepared and based on unit throughput. it showed depreciation of 53.200993 per cent for assets acquired in 1927 and decreased to 3.036687 per cent for assets acquired in 1943. Service units such as steam, electric and water plant, residences and warehouse, were depreciated on a straight line basis from year of construction to 1963. Transportation and fire equipment could be given observed depreciation.

▸ **Madison valuation.** A reconciliation of book value with historic cost of Madison assets was made. A book value of $2,001,000 was decreased about $70,000 for installation costs

FIG. 3. Calgary-Lethbridge gas transmission system.



Oil and Gas Products plant.

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not written off and for fixed assets since removed. An addition of about $7500 covered items charged to expense but considered to be capital expenditure. A few items were susceptible to application of reproduction cost and they added about $4400. Some items covering reagents used in scrubbing, some transportation charges and construction equipment aggregating $48,500 were added, bringing the total historic cost to about $1,991,500.

Intangibles. To this was added 9 per cent to cover intangibles of construction and legal costs.

Going concern. To the total so found, the Board added 5 per cent for the value as a going concern. One witness had put into his valuation a lump sum of $200,000 to represent the added value of a going concern over the value of constituent parts. The Board recognized the validity of the principle, but in view of existing circumstances limited this item to 5 per cent. The reconciliation brought historic cost and book cost to a common figure of about $2,279,000 before depreciation or $1,707,500 after depreciation.

Working capital. Addition of working capital and prepaid Girbotol royalty brought Madison base rate to about $1,919,000.

▸ **Annual depreciation for period.** Having fixed the rate base and method of depreciation of various parts, depreciation charges for each of the four years entering the study could be used in arriving at the money value of depreciation for each year.

▸ **Return on investment.** Return on investment was set at 7 per cent annually on the rate base for each year. The rate base is never static but is annually decreased by depreciation for the year and increased by new capital expenditure.

Before setting the rate of return at 7 per cent, the Board reviewed the evidence, which had involved rate of return on other investments. It appears that a summary by Professor Andrew Stewart of the University of Alberta, Department of Political Economy, had much influence. He enunciated the principle that: "The rate selected should be sufficient to attract the necessary funds as if the undertaking were to be constructed under prevailing conditions. The constituent elements should be pure interest and a definite return for the assumption of risk; that the incidence of income tax is an element to be taken into account; that the method of financing must be considered; that the risk element is greater in unregulated competitive business than in controlled industries, which are relieved of some of the hazards of free enterprise and that in general the rate of return should be lower than rates under competitive conditions; that physical hazards can be provided for in depreciation rates." He considered further, notwithstanding the difference between Madison and British American that "they should be dealt with on the basis of comparable principles."

The decision says that the two companies should receive a progressive return of capital through operation of depreciation throughout the life of their equipment, and a return of 7 per cent on the unamortized capital.

▸ **British American Utilities.** This review will not go into British American costs in great detail. Its rate base of $771,000 was arrived at by taking its original estimate of cost of new works plus its water system and high pressure gathering lines, depreciated on a straight line basis to the end of 1954. It was considered that the original estimates had included 10 per cent for contingencies (or intangibles) and no general addition was made analogous to the 9 per cent allowed Madison. Additional costs authorized by the Board were allowed as well as extra cost that could be deduced from one contract. Also, office and automotive equipment and working capital and intangibles of 10 per cent of items not included in the original cost of new work. Four-year costs to British American were estimated at $537,000.

▸ **Gas and Oil Refineries.** As no capital expenditures were incurred for gas conservation, no cost allocation was needed and the service of turning over residue gas was recognized by allocating part of the producers' revenue to the company doing the service.

▸ **Wellhead price for gas.** The *just and reasonable* price to be paid producers was found most vexing. Prices in American fields were quoted for sweet and for sour gas. Some prices quoted were "field" price after gathering and others were wellhead price. Some fields had to depend on markets at great distance, some on nearer markets.

One approach to the problem was by taking the consumer price and working back through cost of operations performed until the producer was reached. This led to such absurdities as to cause its discard.

Another approach was from the cost to the producer, making a division between cost of finding and producing oil and gas. This approach again led to absurdities.

The decision therefore had to be along the lines of establishing a value for what had been a by-product of no value in the hope that the price so set would provide enough revenue to the

oil producer to induce his cooperation in saving the gas.

The decision set 3 cents per M cu ft effective January 1, 1947, for the well's share in the market. The gas actually delivered by each well to a collecting line shares in the fuel used in the process, shares in shrinkage arising from removal of natural gasoline and waste fractions, shares in unavoidable handling loss. If gas is delivered in excess of the current market, the excess must be stored, and gas stored by Madison is sold to Royalite at "present worth;" that is, at 3 cents discounted for 15 years at 8 per cent per annum.

Producers delivering to Gas and Oil Refineries will get only 2 cents, the difference of 1 cent being divided ¼ cent to Madison for the service of compressing and ¾ cent to G.O.R. for the service of handling and accounting.

Producers delivering gas to British American will get about the same as those delivering to G.O.R. although it will be after cost allocation. Gas paid for through G.O.R. will be on a basis of actual delivery, whereas gas paid for through British American will be on a ratable share of the market.

▸ **Price to Canadian Western.** The original contract made between Royalite and Canadian Western called for payment of 7¾ cents per M cu ft. This was increased in the 1947 decision to 9 cents. Estimated utility costs to Madison and British American for the four years totaled about $3,162,000. On the basis of estimated gas deliveries this came to 4.713 cents per M cu ft delivered. On adding 3 cents for the 1947 price to the producer this brought the cost to 7.713 cents at the gate. By setting the 1947 price at 9 cents the Board thus allowed for contingencies in realization. The August, 1948 price change merely increases the price to producer and wholesale purchaser by a flat 1¾ cents.

▸ **Effect of the 1947 decision.** Although accounting problems are complex, a value was given to gas that formerly had no chance to participate in the market. The exclusive contract to supply the market was taken from Royalite, but a basis was found for fair replacement.

The price set in the 1947 decision did not attract all the gas that might have been gathered without installation of additional compressor capacity. Revenue from a barrel of 42-deg oil is now $3.70 and if 10,000 cu ft is produced with each barrel the 1947 price yields only 30 cents if there were no handling losses. Hence any collection of gas that hazards a decrease in oil production will be avoided. The 1948 price increase is hoped to prove an incentive for saving gas.

The U. S. Supreme Court in a 5-to-4 decision upheld the right of the state of Mississippi to place an excise tax or franchise tax on an out-of-state gas pipe line company even though the company does only interstate business in the state. The case was appealed by Memphis Natural Gas Company. The majority said Mississippi was within its rights in exacting compensation for protecting the company's activities.

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▸ **Appeals against decision.** Canadian Western had been selling gas to domestic consumers under rates fixed or approved by the Public Utilities Board. The Calgary rate calls for $1.50 for the first 4000 cu ft monthly and 25 cents per M cu ft for all additional gas, net if paid promptly. Its average return from domestic consumers is stated to be about 28 cents. No appeal was made for an increase in domestic rate following the 1947 decision. Apparently the incidence of taxes and related matters influenced Canadian Western in the decision to absorb the increase of 1¼ cents at the date.

The nitrogen plant of Consolidated Mining and Smelting Company has a very heavy and consistently uniform load. Consolidated purchased the plant from the Dominion Government, who had constructed it as a war industry. The purchase was effective on May 1, 1946, and was thus almost at the close of the hearing, although negotiations had been proceeding prior to that date. The plant gets gas at cost plus a small transportation charge and the increase in cost affected the plant directly to the extent of the increased cost.

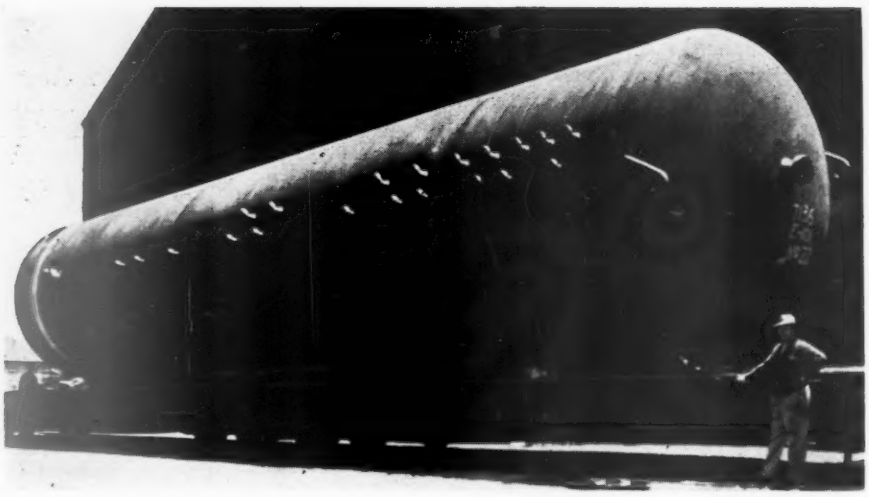
Consolidated protested paying the higher cost, and the Board in rejecting the application noted that cost of gas in 1945 was only $231,000 out of a budget of $3,110,000 and was the smallest item in the budget. Other considerations made it impossible to set one price for one large consumer and a different price for another even larger consumer.

Early in 1948 a committee of Turner Valley producers asked for an increase in wellhead price to 6 cents, thus doubling the return to the producer. A hearing ensued at which argument could be presented, and the decision to increase the price to 4.75 cents to the producer (an increase of 1.75 cents) was coupled with an equal increase at the Canadian Western gate, and this brings the price to that company up to 10.75 cents. It is probable that an application will be made by Canadian Western to the Public Utilities Board to pass this increase on to the consumer.

▸ **Bow Island storage.** On August 20, 1930, Royalite and Canadian Western entered into an agreement for gas storage in the depleted Bow Island field. Royalite was to supply surplus gas to Canadian Western at the Turner Valley gate. The gas would be scrubbed since it entered the same stream supplying the market. Canadian Western was to erect compressors at Bow Island with a capacity of 3,000,000 cu ft a day and take action to prevent leakage from old wells. If storage appeared feasible the compressor capacity was to be increased to 5,000,000 cu ft a day, and this increased capacity was installed. Royalite received no current payment for gas supplied nor did Canadian Western charge for transportation and compression. The stored gas then became the joint property of the two companies in equal shares. Gas delivered was metered and engine fuel was deducted as well as a blanket 10 per cent to cover possible loss. When used from storage Royalite is to receive 25 per cent of the average price realized by Canadian Western during the preceding 6 months or a minimum of 4 cents per M cu ft.

From the beginning of storage in 1930 to 1939 about enough gas was stored to meet a year's demand on the Canadian Western system. In 1939 Turner Valley gas cap production was curtailed to the minimum needed for the market and further storage would have meant unnecessary withdrawal from Turner Valley gas cap, so storage in Bow Island was discontinued.

When in 1945 gas from crude oil wells was being picked up in excess of the summer market demand much of the excess was stored in Turner Valley, but in order to compress all the excess, more compressor capacity would be needed. At the same time there was idle compressor equipment at Bow Island. The excess gas no longer belonged to Royalite but belonged pro rata to all producers. If Royalite wished to continue the former arrangement it would be necessary for them to purchase from Madison. Royalite indicated that it was no longer interested, but Canadian Western decided to take the off-peak surplus and use its equipment for storage. The Board considered that this practice somewhat relieved the need for more compressor capacity in Turner Valley and ruled that the price for gas stored in Bow Island shall be the same as for gas stored in Turner Valley, but because it must be scrubbed and compressed before entering the 16-in. transmission line, cost of scrubbing and compression will be added. ★ ★



A 75-ft petroleum refining vessel starts first leg of its journey to a foreign installation. Called a propane decarbonizing tower and destined for a pressure operation of 500 psi, the 175-ton vessel combines a 12-ft diam with an unusual steel plate thickness of 2⅝ in. It was designed and constructed by The M. W. Kellogg Company.

Special Propane Decarbonizing Towers

Two propane decarbonizing towers, each 12 ft in diam, 75 ft in length, and of 2⅝-in. wall thickness, have recently been completed at The M. W. Kellogg shops in Jersey City. They will be shipped overseas for installation in two foreign refineries. Because of the rare combination of plate thickness and vessel diameter, fabrication of the 175-ton vessels required special equipment and manufacturing skill of the first water.

The specification of 2⅝ in. for wall thickness is particularly noteworthy since most pressure vessels are less than 1½ in. in thickness. Every quarter-inch added to wall thickness introduces bending, welding, and handling problems far greater than those expected from vessels of smaller proportions. Pressure vessels employing 2⅝-in. steel plate are rarely made as large as 12 ft in diam and 75 ft in length because of the extreme difficulty of fabrication.

The unusually thick 2⅝-in. wall of these two vessels was required to withstand a high internal pressure—approximately 500 psi — and additionally to provide ⅛ in. of corrosion allowance due to the presence of active sulphur compounds in the reduced crude oil that will be processed. The vessels were tested hydrostatically to 900 psi. To provide an ample margin of safety they were designed with a safety factor of five, that is, to withstand five times the actual working pressure of 500 psi.

The principal material of construction was a high tensile strength carbon-silicon steel that, with a tensile strength of 70,000 psi is approximately 30 per cent stronger than usual pressure vessel steels. This strong carbon-silicon steel necessitated precise welding control to prevent cracking of the weld or metal adjacent to the weld and to develop a weld strength equal to that of the plate. Kellogg metallurgists previously had worked out the optimum preheat range for this steel by welding under various preheat temperatures and then X-raying and microscopically examining the metal. This preheat range was accurately adhered to by measuring the metal temperature during shop welding of the vessels.

The thickness of the plate, too, required approximately 24 layers of weld metal in each joint, each layer deposited after careful removal of the slag from the previous layer. All principal joints were welded automatically by a continuous submerged-arc process, with machines incorporating novel mechanical design features developed by Kellogg engineers. This procedure provided uniformly good weld quality while saving more than 50 per cent of the welding time that would have been required by manual welding. The welding of the external and internal attachments was performed manually using a ferritic low-hydrogen type of electrode developed during the war for the welding of armor plate without cracks.

Inspection of welds included the radiographing of all main butt joints, using a 400,000-kva X-ray unit; and magnetic particle inspection of all strength welds not radiographed. In addition to this non-destructive inspection, test plates were welded as continuations of the longitudinal seams, and were tested destructively to verify joint strength and ductility. Tests made on these plates were in accordance with the requirements of Lloyds Register of Shipping Rules for Welded Pressure Vessels. Tests included all-weld tensile, joint tensile, bend, impact, hardness, and photomicrograph specimens. One bend specimen reached 83 per cent without failure although the minimum requirement is only 30 per cent, an indication of the extraordinary care exercised.

As welding unavoidably leaves the vessel with a non-uniform grain of at least three different sizes—weld metal. parent metal adjacent to the weld, and parent metal far from the weld—the finished vessels were stress relieved in specially constructed furnaces to remove locked-in stresses.

Because of its excessive weight and thickness, the flat plate for these 75-ft towers was hot-rolled in six equal sections, again with control of bending temperatures using an optical pyrometer. Despite the thickness of the plate, the sections were rounded up to be well within the tolerances allowed by the API and ASME codes. The six sections were then welded together.

The interior of the vessels contains numerous supporting brackets for steam coils, distributor troughs, and baffles. These were all installed prior to stress relieving treatment. All nozzles and pressure connections on the towers were Magnafluxed to insure freedom from cracks.

* * *

Off to a good Start *at Amuay Bay*

Another Example of Efficient Power at Lower Cost

Shown here in the course of installation prior to housing, each of these four Cooper-Bessemer turbo-supercharged, 8-cylinder, 1,575 hp gas-diesels will drive a 1,100 kw generator in Creole Petroleum Corporation's new refinery power plant at Amuay Bay, Venezuela.

Creole Petroleum installs modern Cooper-Bessemer gas-diesels

Here at Creole Petroleum Corporation's new plant at Amuay Bay, Venezuela, these four turbo-supercharged Cooper-Bessemer LS gas-diesel engines, driving generators, will provide power for refinery operation, for loading pumps, and for discharging oil to tankers at the docks. Twelve additional Cooper-Bessemer LS gas-diesels will power the company's new oil line from La Salina to the peninsula — the biggest diameter oil line in the world today.

Perhaps you already know of the latest Cooper-Bessemer gas-diesel development. It guarantees thermal efficiencies unapproached by the best known performance of engines of any other type, and far surpasses the highest efficiencies of all ordinary gas-diesels even at *fractional* loads!

Long-lasting, trouble-free Cooper-Bessemers of *all* types are noted for their low-cost power, can help any operation get off to a good start in life! *And*, you can always count on these engines for *continuing* performance at its modern best. If you have heavy-duty power needs coming up, it will pay you to check with Cooper-Bessemer.

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Electric Power Generation in Oil Fields

By G. L. OSCARSON, Chief Application Engineer

Electric Machinery Manufacturing Company

Petroleum industry power. The petroleum industry comprises four major operating activities that consume large quantities of electric power. These are (a) drilling; (b) refining; (c) transportation; (d) production.

(a) Drilling is largely done by mechanical means, although many all-electric rigs are in use. Purchased power is frequently not available and where electric drilling is done the power is usually generated on the site. Direct-current motors and generators are used. This equipment is highly specialized and is not applicable to other types of load.

(b) Refineries use large blocks of power due to the immense scope of their operations. Purchased power is usually available at favorable rates. By-product power can frequently be utilized, however, to generate part of the plant requirements. Standard generating units, such as would be used in any large industrial plant, usually suffice. Power requirements are usually quite well defined and load characteristics follow normal industrial patterns.

(c) Pipe-line pumps are commonly motor driven when purchased power is available. When pipe-line units are engine driven, electric power for station auxiliaries is generated in the station. These generators are relatively small. In some cases, they are belt-driven from the main engines. In others, they are coupled to engines provided for that purpose.

(d) Electric power requirements for production are quite different from those described above. They are subject to wide variations in application. Some of the important requirements and how they may be met are outlined.

Production methods. Common production methods include (a) engine-driven jacks; (b) central power units; (c) motor-driven jacks; (d) special types such as Reda pumps.

(a) Engine-driven jacks were the first to be used for commercial oil production. They are used extensively in pumping oil wells.

(b) Central power units utilize pull rod lines to connect a multiplicity of pumping jacks to one central mechanical power unit. These units are widely used for pumping groups of small shallow wells.

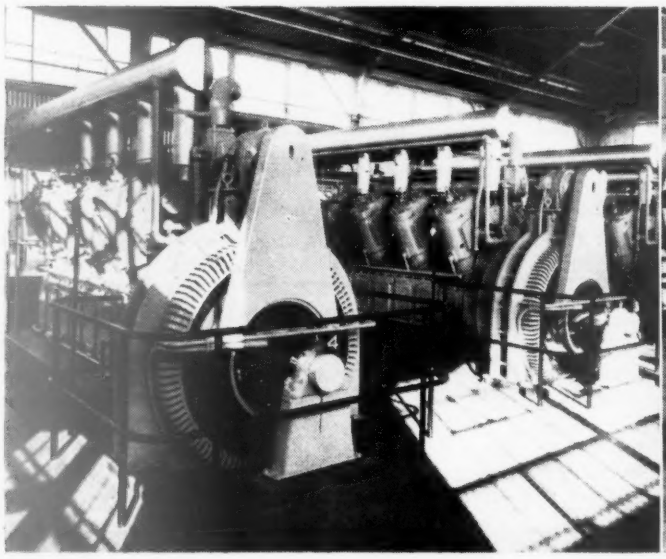
(c) Motor-driven jacks range from about 2 to 75 hp, common ratings being 5 to 25 hp. Motors are usually of the normal torque, normal slip, low starting kva type; however, high-slip motors, on the order of 5 per cent to 8 per cent slip are sometimes used. These motors are frequently installed outdoors and are then of splash-proof construction.

The starting current of the normal torque, low starting kva motors, on full voltage, will be about 5 to 5½ times full load current. On high slip motors, it will be about 4 to 4½ times full-load current. Operating power factor of a typical group of these motors varies from .55 to .70 lagging.

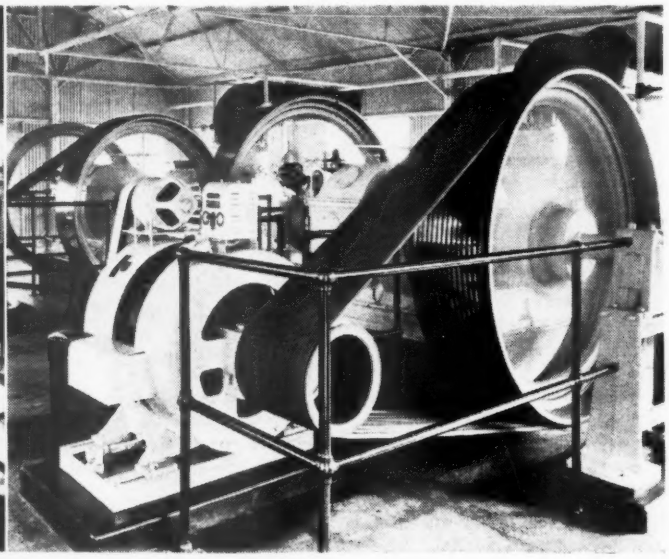
A nominal generating, distribution, and utilization voltage of 480 v is common. This voltage eliminates necessity for transformers and still makes it possible to serve a fairly large number of wells without excessive line loss.

(d) Reda pumps, with direct-connected motors, are long, pencil-like units that fit inside the casing. They are lowered below the fluid level in the well and consequently *may require several thousand feet of* cable to connect them to the source of electric power. They are operated off either

Generating station at South Coles Levee Company, cycling plant, Bakersfield, California, uses four 312-kva, 400-rpm, 2400-v generators.



Two 156-kva, 900-rpm, 480-v coupled bracket type generators, with generator mounted exciters, are used at the Geier-Jackson cycling plant at Grapeland, Texas.



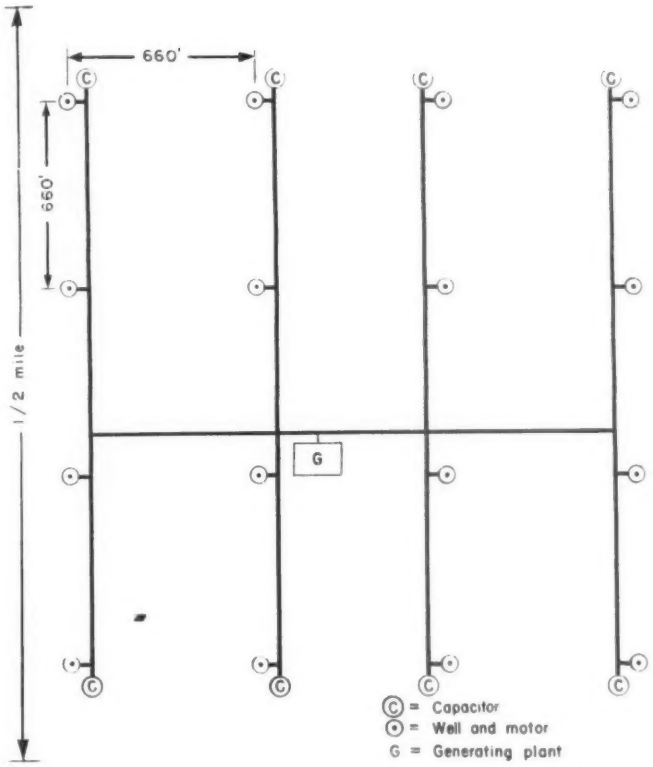


FIG. 1

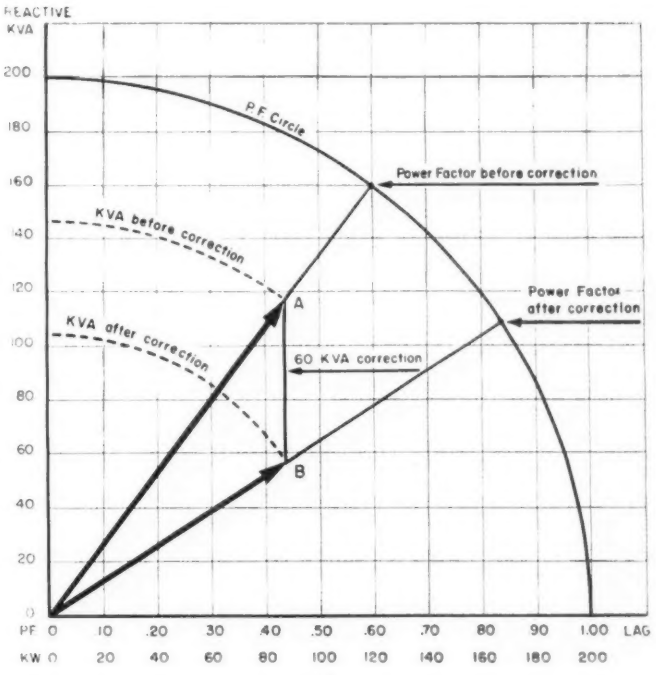


FIG. 4

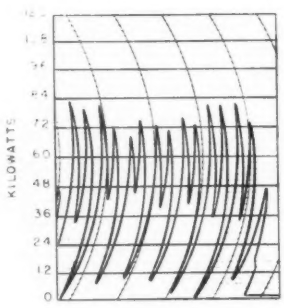


FIG. 2

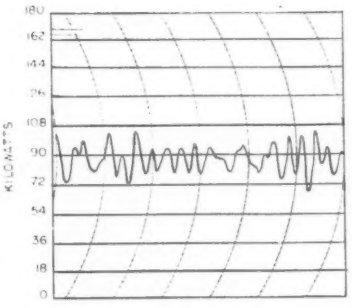


FIG. 3

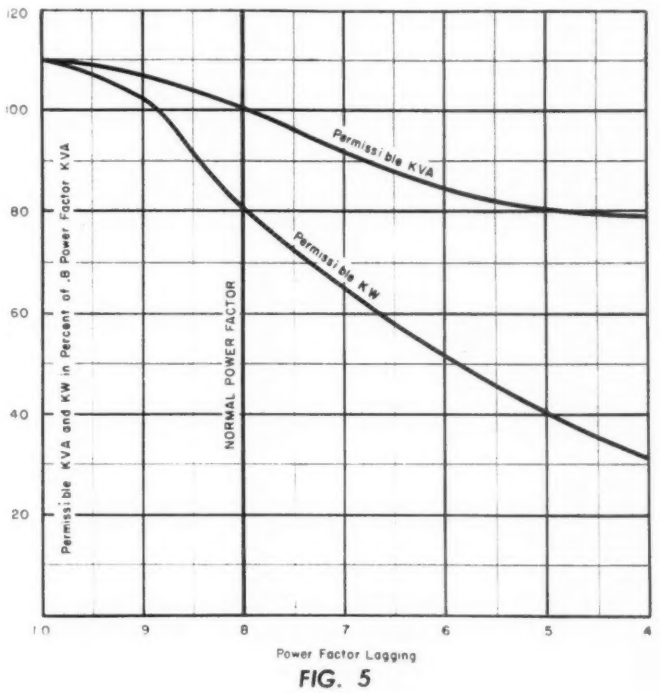


FIG. 5

purchased power or off a generator operating at the site. Generator characteristics are usually quite special for this application. For instance, a wide range of terminal voltages must be available. Also extra capacity to take care of motor starting requirements must be provided.

▸ **Power generator for jacks.** Common practice is to place one well in each 10-acre square. This results in a spacing of 660 ft between adjacent wells. A typical quarter-section layout is shown in Fig. 1. There are sixteen 7½-hp, high-slip (5 per cent to 8 per cent) motors. The generating equipment consists of two 50-kw, 3-phase, 60-cycle, 480-v, .80-power factor units operating in a parallel. *The longest run is approximately 2640 ft or ½ mile. This is about the practicable limit for 480 v distribution.* Eight 7½ kva capacitors are connected as shown, at end of the feeder lines. Disconnect switches are provided so operation at leading power factor at light loads may be prevented. Overall full load power factor is .84 lagging.

Fig. 2 illustrates the load on one motor. Even though this is a fairly high-slip motor and the well is counterbalanced, there is wide variation in kw input. The average load is about 5.8 kw or 6.6 hp. It is obvious that a generator providing power for one such motor will be subjected to wide load swings. Also the generator must have sufficient kva capacity to start such a motor, at the same time maintaining a high enough voltage to develop the necessary torque to start the pump.

Fig. 3 covers a wattmeter chart on the 16 well layout mentioned above. The average kw load is 88 kw and the

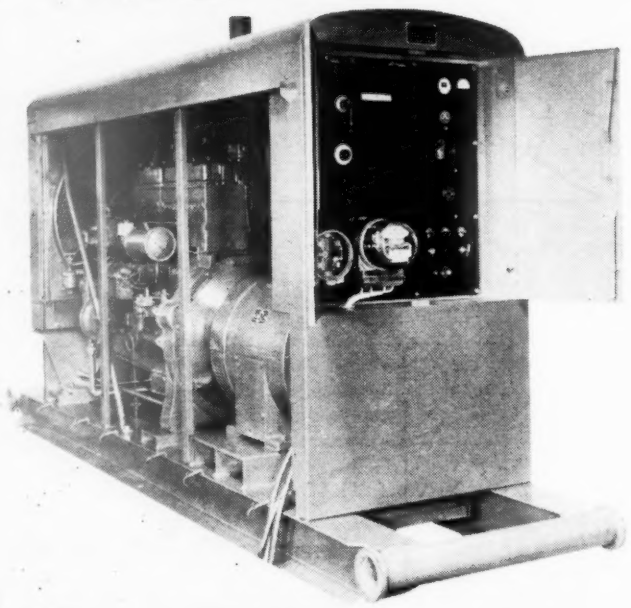
maximum swing is 36 kw. The total load is 105 kva at .84 lagging power factor. The generating plant having 100 kw capacity at .8 lagging power factor handles the load nicely. Without capacitors, the load would be 145 kva at .6 lagging power factor and substantially larger generators would be required.

Fig. 4 illustrates power factor circle and diagram covering the load condition discussed. OA represents kva of the load without correction. The corrective capacity is represented by AB and the resultant load is OB.

With 15 units operating, the voltage dip, on starting the 16th motor, is approximately 8 per cent. *This still provides sufficient torque to start the well and does not interfere with units in operation.*

The above information indicates that where a multiplicity of units is involved, and the *power factor is corrected to .8 lagging*, generating equipment can be installed on the basis of *1 kva per hp of connected load.*

An example of the portable type plant for use in oil fields. This generating unit is rated at 60-kw, 1200-rpm, 240/480-v and is equipped for gas-gasoline-butane operation.



This auxiliary power station of the Signal Oil and Gas Company at Huntington Beach, California, uses two 25-kva, 1200-rpm, 440-v generating sets. These generators employ the Synchrostat voltage regulator.

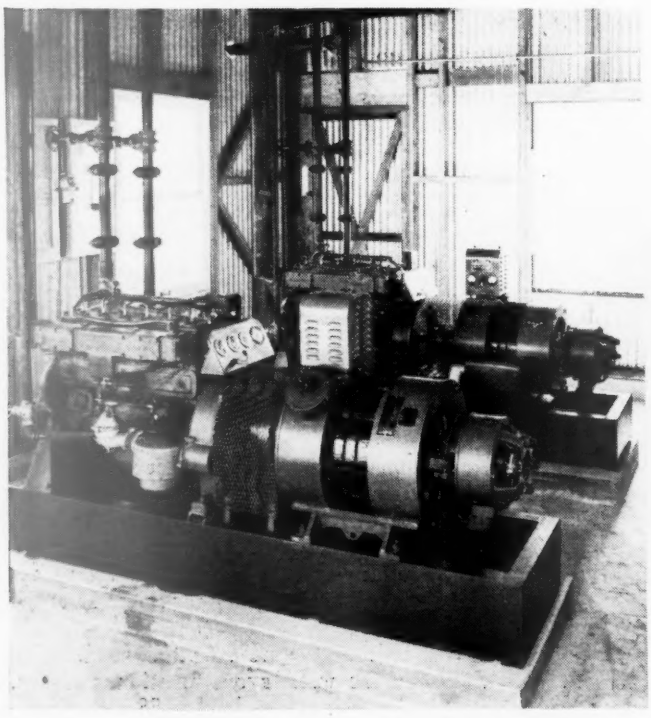
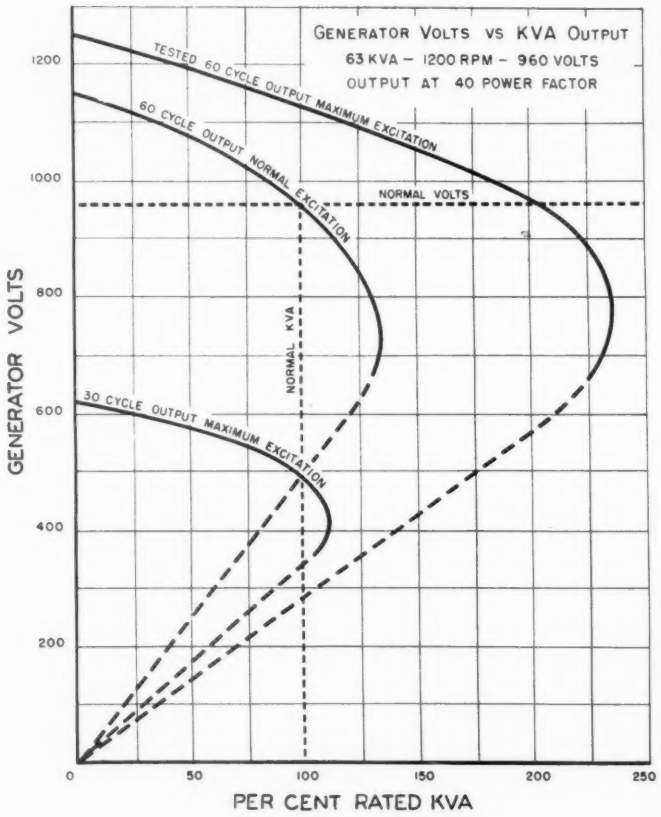
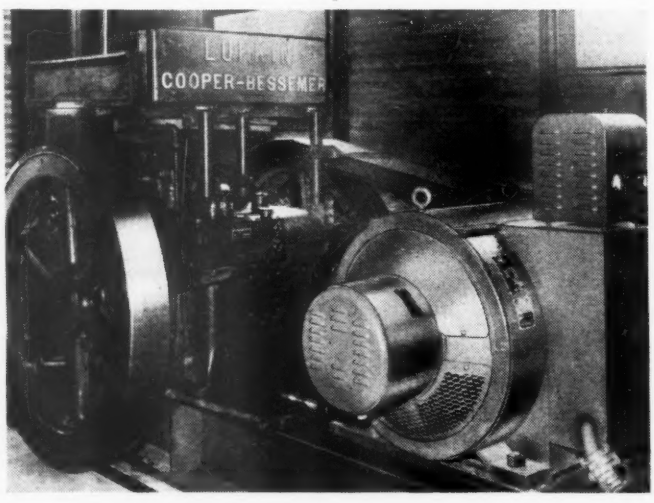


FIG. 6



This oil well installation at Temple, Oklahoma, uses a 50-kva, 1200-rpm, 480-v packaged generator.



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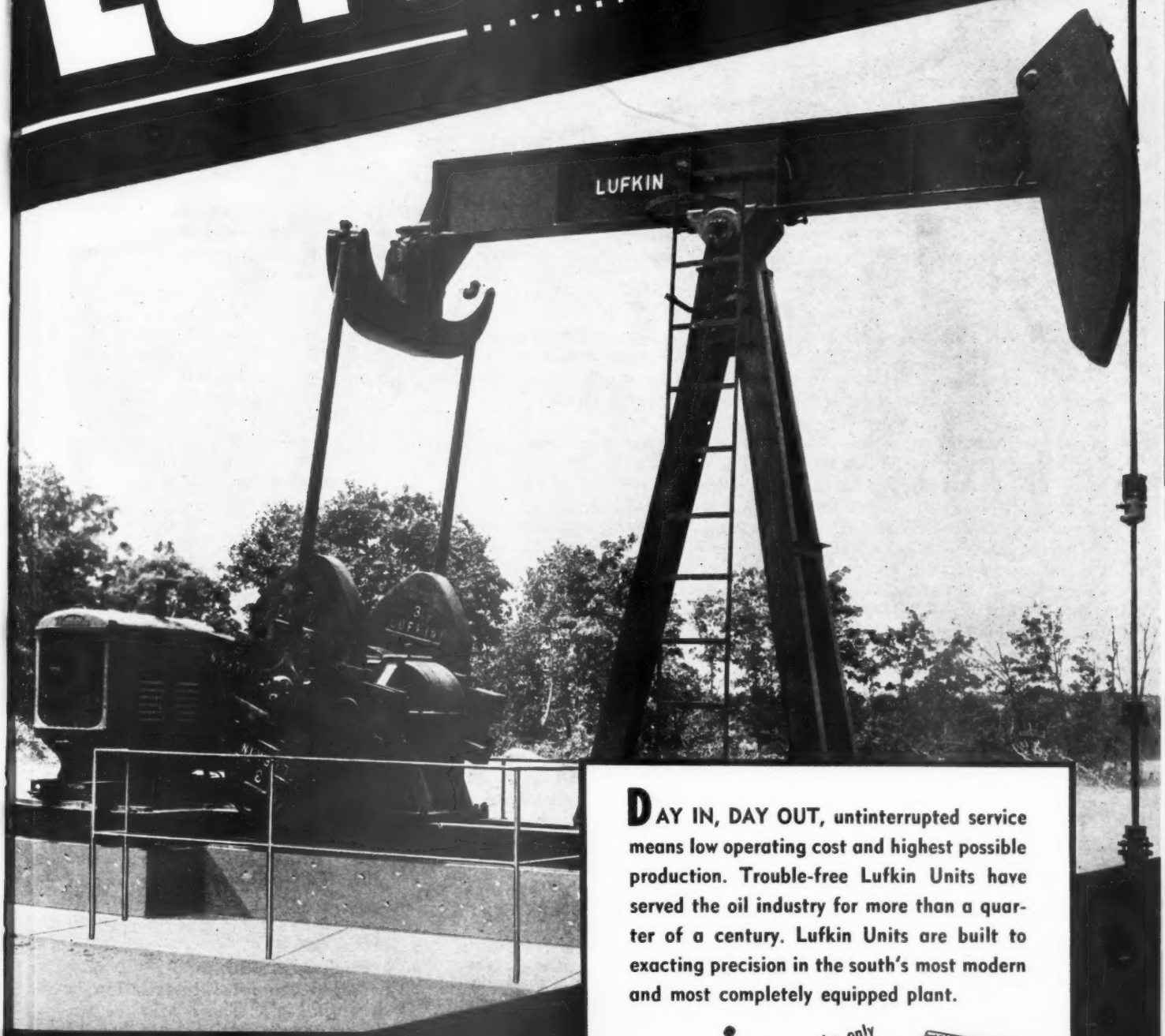

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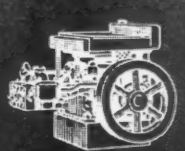

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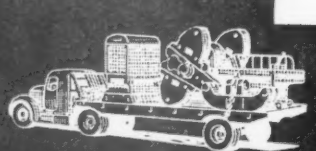

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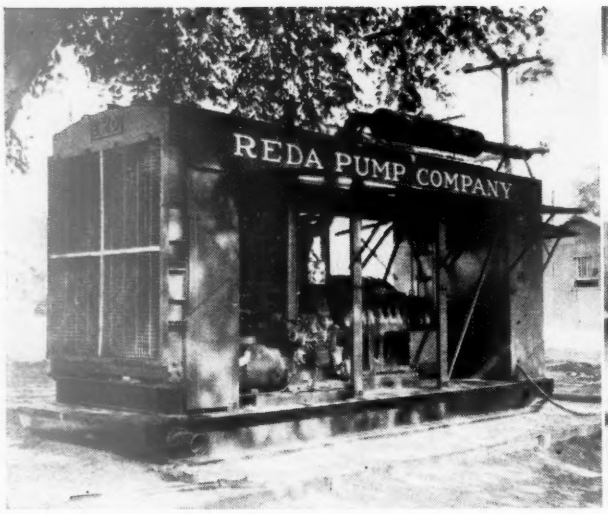
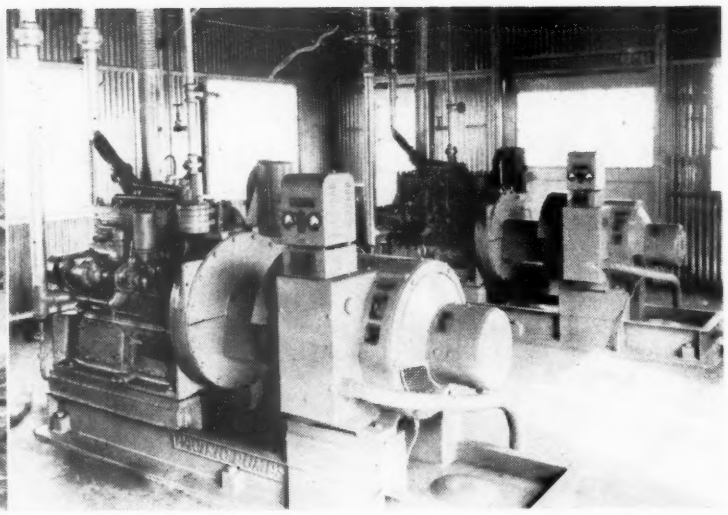


View of an automatic generating plant composed of two 156-kva, 720-rpm generators driven by gas engines. Installed in an Oklahoma oil field.



Installation of the H. W. Snowden Oil and Gas Company, Cement, Oklahoma, uses two Synchrostat regulated sets. Generators are rated at 93.8-kva, 900-rpm, 120/208-v.

At the other extreme, would be the condition, as illustrated in Fig. 2, where a generator would take care of one motor pumping unit. If power factor correction is not provided, it would require a generator of about 25 kva (20 kw at .8 power factor) to maintain sufficient voltage to start the loaded motor. This is equivalent to 3.3 kva per horsepower of connected load.

In most cases the range of required generator capacity will be from 1.25 kva to 1.88 kva per horsepower of connected load. *The best basis for final selection of generator equipment is the application of good judgment based on experience.* When power factor correction is not applied, the power factor will frequently be as low as .6 or even .5 lagging. A standard generator, designed for operating at .8 power factor, will not deliver full load kva under that condition.

Fig. 5 shows the kva capacity of .8 power factor generators when operated at other power factors. This may assist in the application of standard generators to low lagging power factor loads.

▸ **Power for Reda pumps.** Reda pump motors are frequently used in capacities from 20 to 150 hp. They operate at 3600 rpm and have a high starting kva inrush. Since the motor is placed below fluid level in the well, it may be several thousand feet from the source of power. This necessitates a wide range of voltages being available in the generator. Quite frequently 12 generator leads are brought out, permitting connection as 1 or 2 circuit wye or delta. Available voltage are thus 480-830-960-1660.

The reactance voltage drop in the cable to the motor will be quite appreciable during the starting period. To minimize this, the engine speed is frequently cut to 50 per cent while starting the pump. The line frequency is thus 30 cycles and the reactance drop is only one-half of the 60-cycle value. A separate engine-driven exciter is provided to maintain full excitation on the generator at reduced speeds.

Since one motor is applied to one generator, the starting kva, in per cent of generator rating, is quite high. To enable the generator to deliver sufficient kva to start the motor, *field forcing* is frequently used. This merely consists in designing the field so that more than normal excitation can be applied.

Fig. 6 illustrates the extra capacity that can be built into a generator to provide such capacity. With normal excitation, a generator might deliver 130 per cent of rated kva as a maximum value. *By designing the machine for 100 per cent field forcing it is possible to get it to deliver 230 per cent kva.*

The 30-cycle value is also shown in Fig. 6. When full field forcing is applied, it is actually possible to obtain more than the normal 60 cycles, full load rating of the generator at 30 cycles.

▸ **Packaged equipment.** A typical packaged generator installation is shown in Fig. 6. This consists of two 50 kw, engine-driven "packaged" generators. Automatic synchronizers are provided, making it possible to synchronize these units in a minimum length of time and with a minimum amount of skill being required on the part of the operator.

These units, mounted on common sub-bases with their prime movers, are used to provide power for oil field production and other petroleum industry requirements. ★ ★ ★

HOW TO OPERATE A SMALL BOILER

By W. F. SCHAPHORST

MOST owners of small boilers are inclined to believe that such boilers cannot be operated at high efficiency and that only "large" boilers can be efficient. They think that the boiler itself is not at fault, nor the fireman, nor anybody else. They believe that the fault lies in the fact that the boiler is small.

But they are wrong. Small boilers *can* be operated efficiently. Inefficient performance is usually due to blind operation owing to the fact that no visible guides are provided for the fireman. Give the fireman the proper recording devices and operating indicators and if he is at all conscientious he will quickly step up the efficiency of the boiler and make the recorders pay for themselves and earn worthwhile dividends in addition. There are recorders on the market that show steam flow, air flow, and flue gas temperature at a glance. It is not necessary for the fireman to do any guessing with such records before him. He will soon know by observing the records whether the baffles leak, whether the tubes are dirty, whether the setting leaks, whether too much air is used, etc. Give your small boiler the same consideration that you would give to a larger boiler and you will find that the small boiler, too, can be operated at high efficiency.

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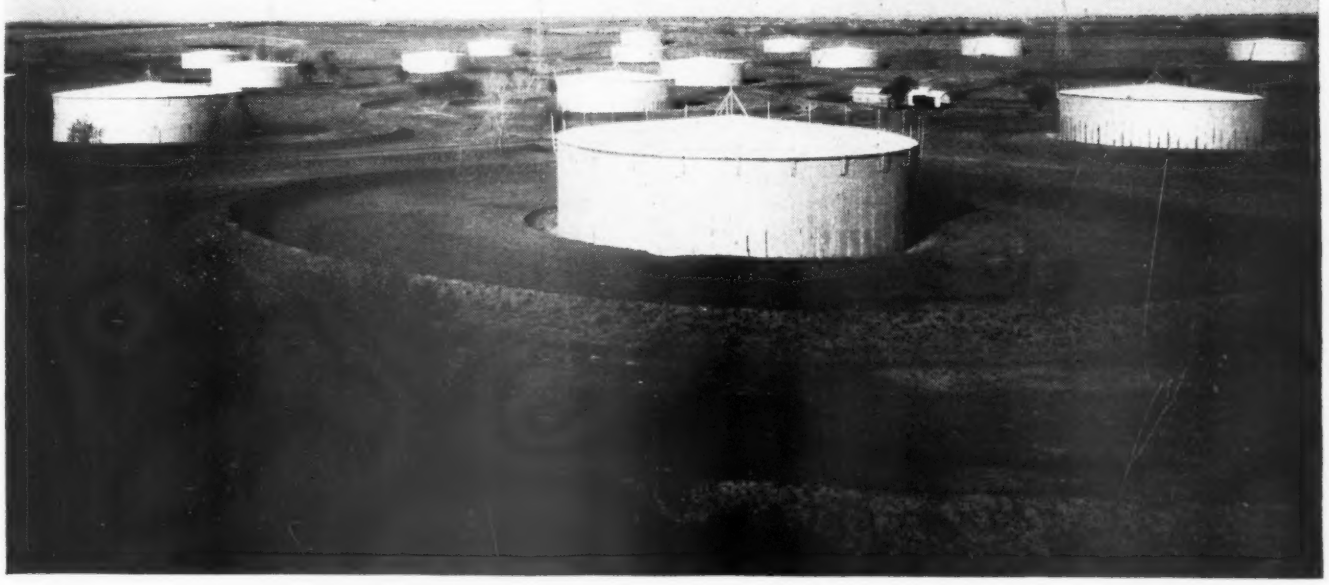

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EXCLUSIVE

Engineering Factors in Measuring Well Depths

By C. R. SEARCY, Lane-Wells Company

ACCURATE oil well depth measurements are of primary importance to protect the investment involved in drilling a well. The expenditure for geological and geophysical data is often of little value unless the depth of the expected producing horizon is fixed accurately below the surface. There are many sources of error in measurement that must be ferreted out and evaluated prior to any conclusions pertaining to a given set of data. Research has uncovered various sources of error in well depth measurements. The magnitude of the effect of these errors on final results and the relative merits of wire line and tubular goods well measurements have been reasonably determined. Field experience, research, and new developments in equipment and technique have made it possible to complete a well effectively in one to two feet of sand.

The drilling of a well may represent an investment of from several thousand dollars to several hundred thousand dollars. The one objective is to find oil or gas and bring it to the surface as economically as possible. Exploration expense, leasing, legal, and drilling costs all enter into the economic picture of oil production or potential production in a "wildcat" area. Probably no other industry has advanced as much in such a short period of time as the oil industry.

Improvements in drilling equipment, technique, and highly technical services have been phenomenal, yet the one factor on which the success of most of these improvements depends is the establishment of accurate measurements. Although the subject of measurement is of primary importance to "hit the bull's eye," it probably receives the least amount of emphasis until the well completion stage has been reached. At this stage, unless preceding work correlates satisfactorily, the problem of correcting and correlating measurement data assumes voluminous and usually expensive proportions. Actually, there have been instances where a well has been damaged beyond repair and abandoned due to the inability to properly establish and correlate the measurement data. Colleges and universities are producing trained personnel for specialized assignments in many fields of endeavor. Nevertheless, the highly important assignment of determining well depths is much more than a part-time job for some member of the engineering staff of a producing company. This part-time rating of a very vital task is not conducive to instilling the necessary degree of "measurement consciousness" within an organization.

During the early days of the oil industry when the size of a well was the main criterion of success and operations were measured in terms of who got there "firstest" with the "mostest," depth measurement was relatively unimportant, because a 3000-ft well was considered deep, and pay sections were often many feet in thickness.

The drilling industry has recognized for several years the validity of drill pipe as the "yardstick" for accurate well depth measurements. The same drill pipe that is used to drill a well is also considered the best media for depth measurement. Unfortunately, the pipe cannot be measured while in place in the well but must be measured in given segments at the surface and projected into the bore hole. Then, as the well nears the completion stages and all bore hole information desired is obtained, the bore hole is sealed off with casing and the drill pipe "yardstick" is set aside. The casing record will occasionally reveal a different total depth figure as the result of using this less desirable "yardstick." Then, as completion progresses, tubing is brought into the measurement picture to further complicate and confuse the operator by indicating still another total depth figure. Therefore, the individual who is charged with the responsibility of well measurement should be constantly on the alert and have at his command all available knowledge of the various measurement media. He should have compared the relative merits of each and the sources and magnitude of errors, because the variety of indicated total depths on a given well can evolve into a vicious cycle of answers that further confuse rather than clarify the problem.

Naturally, then, a determination of sources of measurement discrepancies, together with the ability to evaluate each and combine them into a correlated final analysis, is of paramount importance in this day of highly competitive oil production. Some of the sources of measurement discrepancies are as follows:

1. *Wrong Elevation for Well Zero.* Many times depth measurements are not only complicated by changing measurement "yardsticks," standards and equipment, but are further clouded by changing "well zeros," or starting points. Well zero is certainly one point that should be established *definitely* at the beginning, and from which all measurements should be made, regardless of the "yardstick," throughout the history of a well. Yet, too often, a well is completed from a drilling derrick where the rotary, drive bushings, or derrick floor was used as zero. Then, when a workover job is begun, zero may be changed to ground level, bradenhead, or some other point on the wellhead equipment. Although these points may be logged in the well records in reference to the aforementioned points of the drilling rig, this multiplicity of data encourages error. A suggested means of establishing permanent well zeros, or bench marks, for *each* well would be the setting of a concrete post near the wellhead, or a bolt head in the derrick foundation (if this is a permanent pillar), or driving a steel stake 10 or 12 ft in the ground near the wellhead at the beginning of operations. This permanent B.M. could then be used as the starting point, or zero, of *all* measurements regardless of the operation until the well was plugged and abandoned.

2. *Inaccurate Tape.* The use of varying kinds, types, and versions of tape lines probably accounts for many discrepancies between operators and between operators and service companies as any other single source of error. Measuring tapes become bent, broken and twisted very frequently through rough handling around the rig. When such a tape suffers a service accident, it is usually repaired, but not always in an approved manner, and it is used until a replacement is received. If a tape is broken, it may be repaired satisfactorily with a "butt splice" and continued in use. Occasionally, however, a lap splice is made

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that causes the tape to be shorter and to measure everything longer, so that well depths appear greater than their true depths. Although the use of foreign material to repair a tape is frowned upon, it has been observed that everything conceivable around a rig has been used, including banding iron, soft line, etc., as expedients for splicing and extending a tape line. The inaccuracies resulting from such crude expedients can be visualized readily. The type of measuring tape that is recommended for maximum accuracy is one that is commonly called a steel chain. This tape usually has several desirable features that minimize many sources of error due to improper usage of the tape line. For example: (a) a stop lug at the zero point to provide positive zeroing of one end of the tape line; (b) heavy duty construction to withstand rugged service around the rig; (c) a repair kit and instructions for making repairs to a damaged tape line; (d) proper storage reel with wiper attachment so that the tape line is wiped clean and oiled each time it is reeled up or unreeled; (e) tape 100 ft long graduated in ft, tenths of ft, and hundredths of ft for easy recording; (f) tape line tagged as to tension under which it was calibrated while being supported throughout its length, supported at each end, or suspended vertically, and the atmospheric temperature at the time of calibration. For the utmost accuracy, temperature corrections should be applied to the tape line.

3. *Inaccurate Reading and Recording.* Even with the best of equipment, the desired results cannot be expected, unless the personnel are trained properly in its usage. Many measurement procedures are practiced by operators in the oil field, but one that probably offers the best results is the "three man measuring team." This team is composed of a tape holder, reader, and recorder. The holder places the zero lug of the tape at one end of the subject to be measured. The reader aligns the tape, applies proper tension for the situation and reads the measurement. The recorder writes down the figure called out by the reader and, at the same time, repeats the figure. This practice eliminates several possible sources of error.

4. *Stretch of Tubular Goods.* It is universally recognized that tubular goods will stretch when a load is applied. The amount of stretch is a function of the load, or depth suspended. For example, a joint of pipe on the lower end of a string stretches very little compared to a joint of pipe at the surface with 8000 ft of pipe suspended from its bottom end. It has been determined that 8000 ft of a uniform string of casing, tubing, or drill pipe of a given size will stretch about 44 in. suspended in air, 38 in. suspendid in water, and 36 in. suspended in 12-lb mud (see Fig. 1). This means that a string of pipe would stretch when lowered into the hole so that the measurement on the rack would indicate a bottom measurement less than true depth. Consequently, this stretch factor should be taken into account when correlating measurements between drill pipe, casing, and tubing "yardsticks," particularly where each yardstick has been measured under different conditions or circumstances.

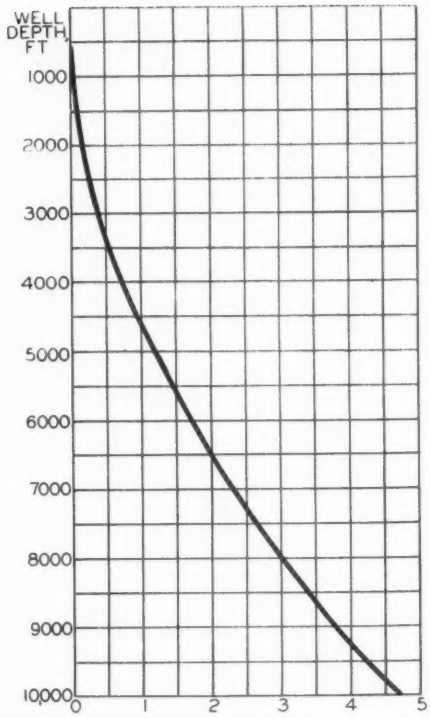


FIG. 1. Stretch of casing, tubing or drill pipe in 12 lb (per gallon) mud. (Reference: Sprang-Chalfant Handbook.)

It is considered the best practice to measure pipe while pulling it *out* of the hole in a *strain* (with the pipe hanging in the elevators before its weight is set in the slips). This method measures the pipe while it is in tension and no correction for stretch is necessary. Although this strain measurement is subject to error due to wind blowing the tape, this source of error can be overcome by using a measuring rod (see Fig. 2). Such a rod can be made of small pipe, or sucker rods, with a shoulder on one end and a short section of graduated tape at the lower end.

5. *Temperature.* Tubular goods are subject to changes in length as a result of changes in temperature. The same is true of measuring tapes and wire lines used by the various service companies. For commercial casing, drill pipe, and tubing the coefficient of expansion has been determined (Spang-Chalfant Handbook) as coef. $= 6.9 \times 10^{-6}$ per ° F (over a range of from 0° F to 400° F). The length of a pipe or string is

$$L_t = L_o\ (1 + .0000069 \times t). \quad (1)$$

Where:

L_o = length at temperature before heating.

L_t = length at temperature after heating,

t = change in temperature (in ° F).

For example, if a string of pipe is 8000 ft in length at 70 F and heated to a temperature of 150 F its true length would then be:

$$L_t = L_o\ (1 + .0000069 \times t).$$

Substituting:

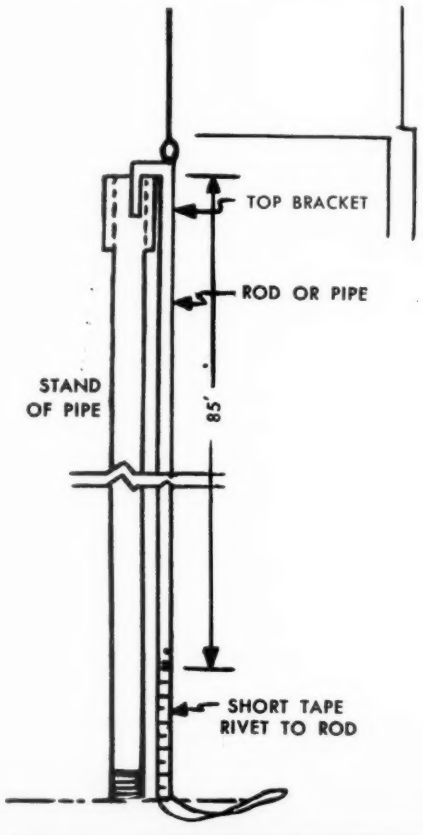
$$L_t = 8000\ (1 + .0000069 \times 80\ F).$$

$$L_t = 8000\ (1 + .0005520),$$

$$L_t = 8004.41 \text{ ft at } 150 \text{ F}.$$

This temperature factor is further depicted in Fig. 3 for depths to 10,000 ft and temperature changes of from 40 F to 80 F. It can be seen readily that changes in length due to temperature may become appreciable at relatively shallow depths. It is common practice, however, not to correct for

FIG. 2. Suspended rod for measuring pipe standing in derrick.



differences in atmospheric and down-the-hole temperature when measuring tubular goods. All surface measurements are comparable, therefore, without making the temperature correction, particularly those made coming out of the hole with the tubular goods in a strain.

6. *Confusion of Measurement Methods.* An exact determination of the measurement method is essential prior to any analysis or attempt to correlate a given set of well measurement data. That is, was the pipe measured in a strain, standing in the derrick, or resting on the rack? The only true strain measurement situation is when the single, double or thribble is pulled up into the derrick and the full weight of the pipe below is fully and freely suspended. The method of pulling a segment of pipe up in the derrick and setting the slips, partially slacking off on the block and then measuring around elevators, is not true strain conditions. This system is more nearly comparable to pipe standing or rack measurement, but this practice has certain advantages, particularly with threaded pipe, such as:

(1) Placing the pipe and tape in parallel planes.

(2) Minimizing the opportunity for error by measuring in long segments.

(3) Measuring length after thread makeup (preferably coming out of the hole after drilling operation).

This procedure is subject to error, however, in measuring around the elevators, unless an offset is used (see Fig. 4), and purposely neglects stretch. It is considered reasonably accurate, however, and is practiced by a number of operators. Pipe measured while standing in the derrick is a very common practice, because of convenience and perhaps speed through measuring several stands at a time. This also is subject to several errors:

(1) Bow in pipe and tape not the same.

(2) Inaccurate tape.

(3) Inaccurate reading and recording of tape measurement.

(4) High wind blowing the tape.

(5) Stretch of pipe neglected.

(6) No measurement of thread makeup.

The principal advantage offered by this method is perhaps the reduction of opportunity for error by measuring in "doubles" or "thribbles," whereas, pipe measured on the rack in singles multiplies the opportunity for error by two or three times.

7. *Use of Stenciled Lengths on Pipe.* This procedure has its advantage as a time-saving factor, but is not recommended for accuracy. A service accident might occur occasionally to a pipe string that would void these stenciled lengths. For example, when a string of pipe becomes stuck and is pulled on excessively for any reason, the pipe acquires a certain amount of permanent stretch. Therefore, the new lengths will not agree with the stenciled lengths and the pipe should be remeasured. Furthermore, these stenciled lengths may or may not state whether they were measured in a strain or otherwise, which is confusing.

8. *Well Plug-backs.* All too frequently when plugging back a well to upper pay horizons, the upper zone is "aimed at" by deduction. The distance to plug back is measured and deducted from the total tally, hence a new total depth is established. Although this system is workable, it would be definitely more accurate if both totals were remeasured: that is the length removed from the string, and the length remaining. The two measurements should certainly check each other and provide a double check on the original measurement.

9. *Personal Factor.* The exactness of observation and recording by the personnel controls the accuracy of all measurements under any condition. Several very common errors are committed, however, that are directly attributable to mistakes made by responsible personnel. These errors have been found to be:

(1) Drilling out the float plug.

(2) Plug not drilled, just checked.

(3) Omission or addition of subs.

(4) Changing joints of pipe in a string without measuring.

(5) Changing kelly or drill collars.

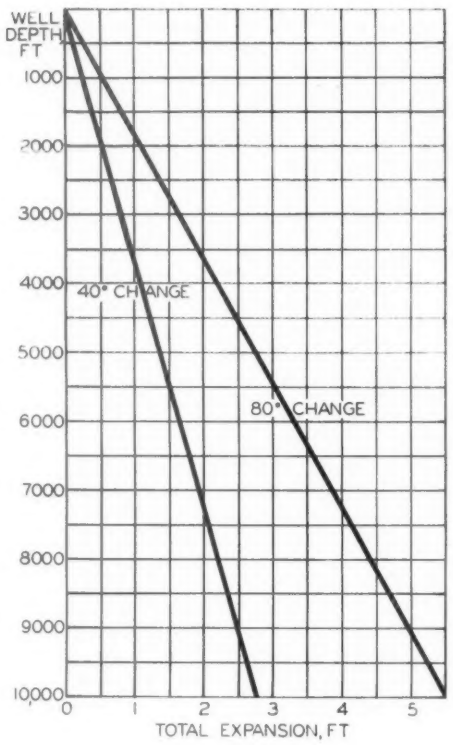
There are other sources of error that are disturbing, both to the well operators and the service companies that can be classified as "well condition." For example:

(1) Cement plug drilled with water.

(2) Well fluid conditions.

(3) Plug drilled with small bit.

Although these errors are recognized readily, their exact determination is sometimes very difficult. For instance, in the case of a cement plug being drilled with water, the volume of cuttings removed from the hole is dependent upon fluid pressure, rate of flow, time pumped, and area of annulus. Very frequently, therefore, when circulation is stopped, many cuttings fall back to bottom. This "fill-up" on bottom with cuttings is often a gradual



FORMULA

$Lt = Lo\ (1 + .0000069 \times t)$

Lo = Length in feet at surface

Lt = Length at well temperature

t = difference between average temperature at surface and average well temperature

FIG. 3. Expansion of tubular goods due to temperature. Measured at surface and entered in well fluid. (Spang-Chalfant Handbook.)

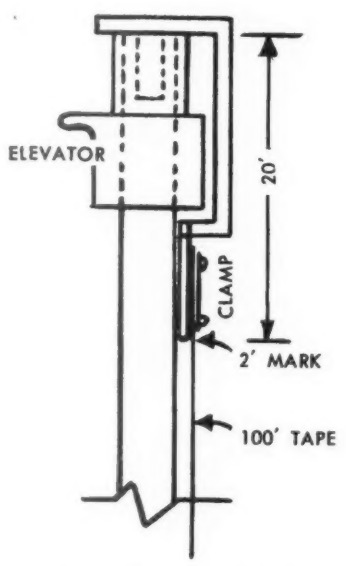


FIG. 4. Elevator offset for measuring pipe in strain.

process, but by the time the service company gets to total depth with a tool, the hole may have filled up. Consequently, the depth as recorded by the service company can be several feet shallower than that of the pipe length measured out of the hole.

Another situation that has no appreciable effect on the pipe measurement but causes considerable trouble to the service companies is well fluid condition. When the well fluid is conditioned sufficiently, providing a homogenous mud column, the service companies can perform their services with speed and efficiency. When the mud column is caked, bridged over, and settled out on bottom, however, the service companies have difficulty getting down with small, light tools and measurements may not agree. Many times an exact determination by the service companies of actual total depth is rendered impossible due to "mud settled out."

In addition to the two conditions mentioned, drilling cement plugs with undersized bits often causes measurement trouble. This procedure is sometimes used from convenience rather than necessity. The service companies, however, receive their cue to proceed with caution immediately upon comparing casing and bit sizes. If a cement plug is drilled with an undersized bit, a cement sheath frequently remains on the inside of the pipe. This may or may not be detectable until total depth is reached, and sometimes only after perforating. The result is that this cement cake sloughs off and fills up the bottom, thereby causing measurement discrepancies. The most serious consequence of using undersized bits is that tools often become stuck during the perforating process due to the cement sloughing off.

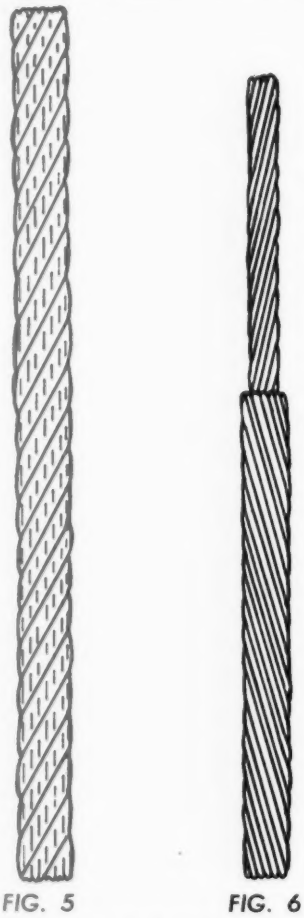


FIG. 5 FIG. 6

At left is stranded cable. (6 strand, 7 wire). At right is R/C cable design. (Reverse concentric).

When a well progresses into the completion stages various service companies are used to perform a variety of technical services. In addition to the technical service applied, the operators depend to a large extent on the service companies for a measurement check. The well measurements determined by the service companies and the operator do not always agree, and many times the disagreement can be attributed to one or more of the following reasons:

(1) Operating speeds while measuring.
(2) Type of equipment.
(3) Well fluid condition.
(4) Wrong zero or bench marks used.
(5) Cable spooling.
(6) Temperature differences.
(7) Measuring system differences.
(8) Measurement calibration.
  (a) Mathematical errors.
(9) Straight-line measuring device.

There are safe, economical, and efficient limits on the rate of operation of various types of wire line well servicing equipment. These limits are determined largely by the individual well condition or situation and the type of equipment being used. Any attempt to exceed these limits under the existing conditions not only endangers the well, but appreciably distorts the accuracy of measurements. Abnormally high operating speeds on the part of a service company sometimes contributes to measure disagreements.

Each service company has special assemblies of well servicing equipment to perform particular services. Generally, however, these particular units are equipped with a cable for lowering and raising the tools, drum for storage of cable, drawworks or hoist, sheave, and weight indicator. Other tools and accessories vary with companies and units within a company. The cables may vary in size and design but are usually relied upon to establish measurements. The manner in which this cable is measured may be entirely dependent upon the accuracy of the sheave over which the cable is suspended. This sheave measurement is sometimes supplemented, however, with "flagged lines," average stretch factors, predetermined resets of the odometer or footage counter, and other correction factors.

Regardless of the manner in which the cable is measured, the design of the cable is of primary importance. The stranded cable (Fig. 5) is satisfactory for various uses such as swabbing, coring and winching, but not sufficiently stable for accurate measurements. Tests on the stranded cable reveal that, if rotation is restrained, the elongation is about 1 per cent, and, if allowed to rotate, 6 per cent. In the initial runs of a new cable, it will stretch as much as 75 ft in 8000 ft. Therefore, the characteristics were unpredictable and measurement results unreliable. The reverse-concentric wire line (Fig. 6) is perhaps less desirable for other uses, but it is better for well measurements, because of its resistance to service accidents and its mechanical stability characteristics.

Well fluid condition oftentimes dictates the rate at which a particular service can be performed. For example, if the mud is caked on the walls, bridged over and settled out on bottom, operations will be retarded. This is particularly true with tools that are lowered and raised on wire lines. Not only is additional time required to perform the service, but correlation of the depth measurement is usually unsatisfactory.

Many times a technical service operation is commenced on a well before the operator or representative arrives

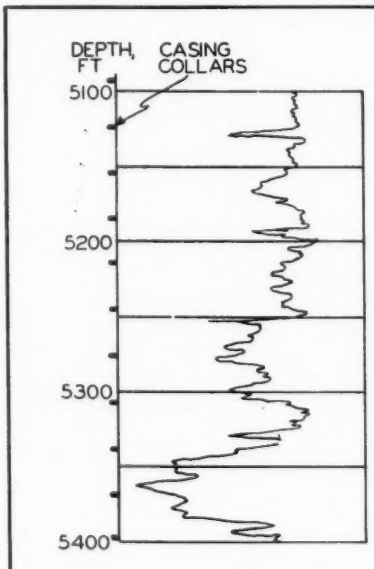
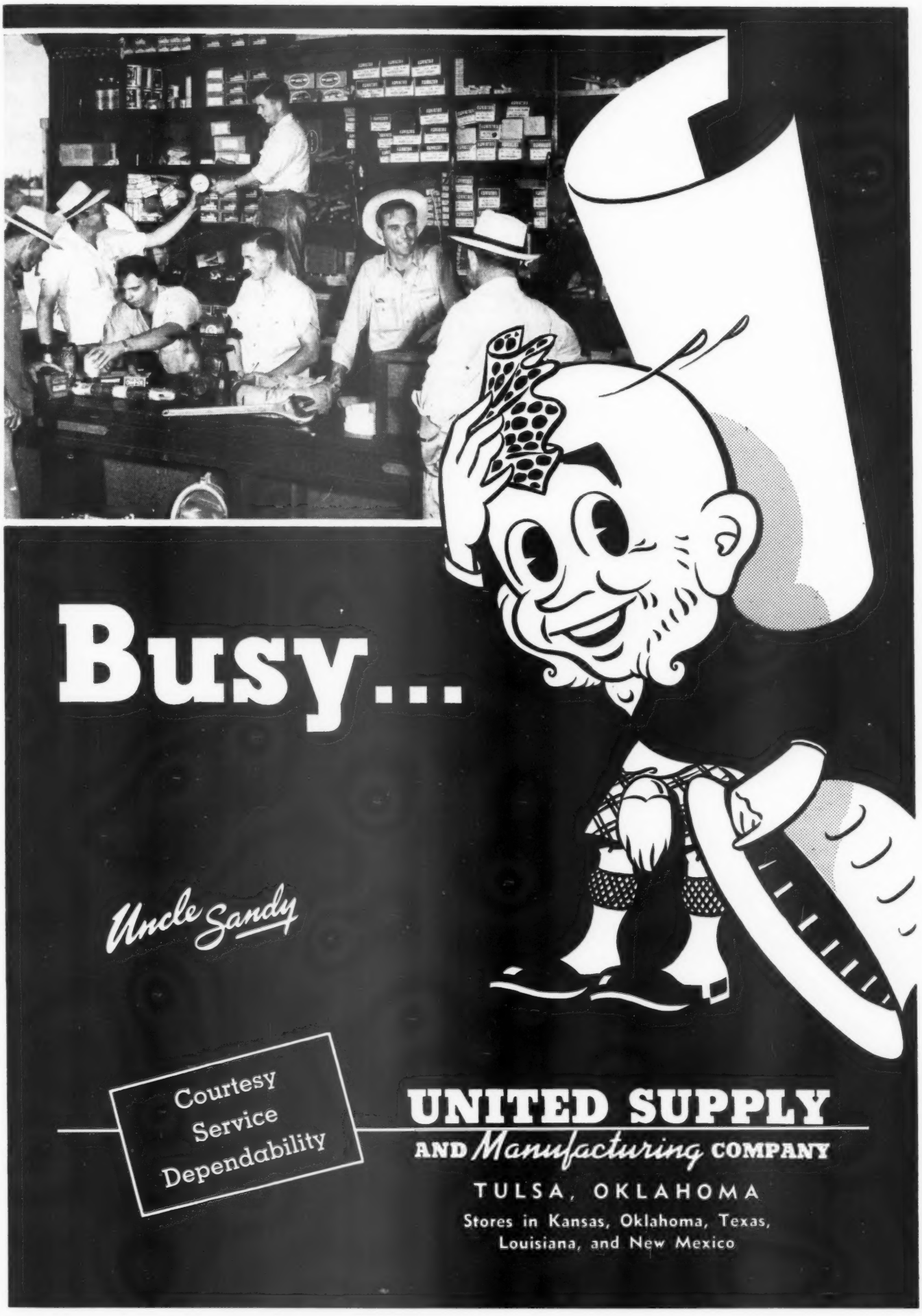


FIG. 7. Casing collars located simultaneously with formation log.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to supervise the application. Quite often the zero or starting point for measurement purposes is obtained from a member of the crew, and, occasionally, this zero point is incorrect and must be changed during the course of operation.

"Believe it or not," the actual spooling of the cable on the service company equipment affects the accuracy of well measurements. A smooth, evenly balanced cable spooling will enable even inexperienced personnel to produce accurate measurements. However, if the cable reels up and unreels unevenly, rough and out of balance, linear instability is induced into the cable so that it is difficult for the best experienced personnel to control and produce accurate measurements.

The effect of well temperatures on wire lines is appreciable, however, not to any lesser or greater extent than the effect on tubular goods. Therefore, since the magnitude of temperature effect upon wire lines closely parallels that of tubular goods, the temperature correction factor of $Le = 1 + .0000069$ is considered applicable. Some service companies calibrate their wire lines under test well conditions where the temperature effect is measured directly in the calibration. Others calibrate their cable and theoretically apply the temperature correction factor. There are still others who ignore the temperature factor and adjust their measurement to the average.

There are probably as many wire lines measurement systems as there are service companies. However, these various systems generally fall into two categories: the integrated multiple system and the single system. The integrated multiple system, usually consisting of flag line and sheave measurement, together with other correction factors, is considered most reliable, because of its cross checking features. The single system measure method may be equally as reliable as the multiple system. It is subject to variables, however, the magnitude of which are not always determined precisely. These variables may be: change in sheave temperature, poor alignment of equipment, slippage of sheave, mud or ice cake on sheave, and others. Regardless of the system used, any system that relies upon the sheave measure alone for accuracy cannot be expected to produce results as consistent as required under present day standards of performance.

Probably the first question to be asked about any measure system is "What was the yardstick?" In the case of the operator, the yardstick is usually drill pipe, casing, or tubing. In the case of the service company, however, the yardstick is usually the wire line. As with other measurements such as volume, weight, or distance, there are certain standards, and the "yardstick" used should be checked frequently against a standard. The standard may be a test well, tension analysis, test road, straight-line measuring device, or averages as determined from an operator's well. However, irrespective of the standard, or system practiced, it is believed that the objective of all service companies is to arrive at the recognized field yardstick "tubular goods in a strain."

It has been said that "He who makes no mistakes does nothing. He who makes too many mistakes loses his job." Simple mathematical mistakes are committed occasionally by both operators and the service companies which, should they be left uncorrected, would prove expensive and embarrassing to all concerned. However, if the service company has a good, sound, simple cross-checking measuring system, the measurements by an operator and by the service company can be correlated and reconciled quickly.

There are many versions of straight-line measuring devices, and all probably have merit. Further, it is believed that when used as an integral part of another system they are all quite satisfactory. The straight-line measuring device is not considered consistently accurate, however, when used as a single system and should not be relied upon completely, unless (1) They are checked frequently against a standard, and (2) proper corrective factors are used. Since the cable is passed over a steel measuring wheel with a small ratio of ft per revolution, the measured length of the line depends upon the accurate diameter of the measuring wheel. If the wheel is designed to be used with a 0.060-in. diam wire, a change to a 0.072-in. wire may result in an error of about 3 ft per 1000 ft of well depth. A total change in wheel diam of 0.005 in. due to wear or atmospheric temperature results in an error of about 1.3 ft per 1000. If the measuring device is checked frequently against a standard such as a calibrated measuring head, drill pipe measurement, or integrated with another system of measure, however, the results can be quite accurate.

New tools and technical services are continually being offered to the oil industry. Each new tool or service provides either a saving in time, improvement in technique, greater detail of information, or the solution to some "knotty" problem of long standing. Such a tool was offered to the industry several years ago that provides the solution to several problems. One of the principal problems solved was that of well measurement and measurement correlation. This service is called Radioactivity Well Logging. The survey produces a log of the various formations in the bore hole from total depth to surface of the well, and the signal pickup or instrumentation is not affected by one or several strings of pipe. It is common practice to run a radioactivity well log wherein the formation is logged and down-the-hole bench marks (casing collars, Fig. 7) are established simultaneously. This service provides a measure correlation from surface to total depth that insures accuracy for well completions.

The accomplishment of accuracy in well measurements is analogous to that of an expert rifleman. An expert rifleman chooses a reliable weapon, he thoroughly familiarizes himself with its use, he properly zeros it, and he practices precision and exactness. Results—a high percentage of hits in the bull's eye. The same formula can be applied to accurate well measurement:

(1) Choose a reliable yardstick.

(2) Become thoroughly familiar with its use and application.

(3) Properly zero the yardstick with a standard.

(4) Practice precision and exactness.

(5) Results: More oil per dollar invested.

* * *

Research committee

The Texas Petroleum Research Committee, sponsored jointly by University of Texas, A. & M. College of Texas, and the Railroad Commission, has been formed. Purpose of the committee is to develop a program of research in petroleum engineering with particular emphasis on problems of secondary recovery of oil, improvement of primary recovery methods, and any other means seeking to increase the total quantity of oil recovered from Texas oil fields. Specific problems are to be assigned by the committee to the school best prepared to handle such problems, thereby eliminating overlap and duplication of effort.

Committee members are: W. J. Murray, Jr., chairman, Railroad Commission of Texas; Harold Vance and Albert B. Stevens, Department of Petroleum Engineering, A. & M. College of Texas; Harry H. Power and George H. Fancher, Department of Petroleum Engineering, University of Texas.

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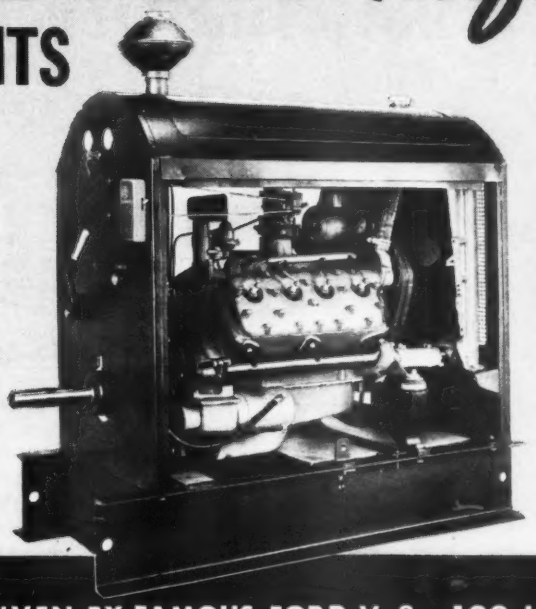

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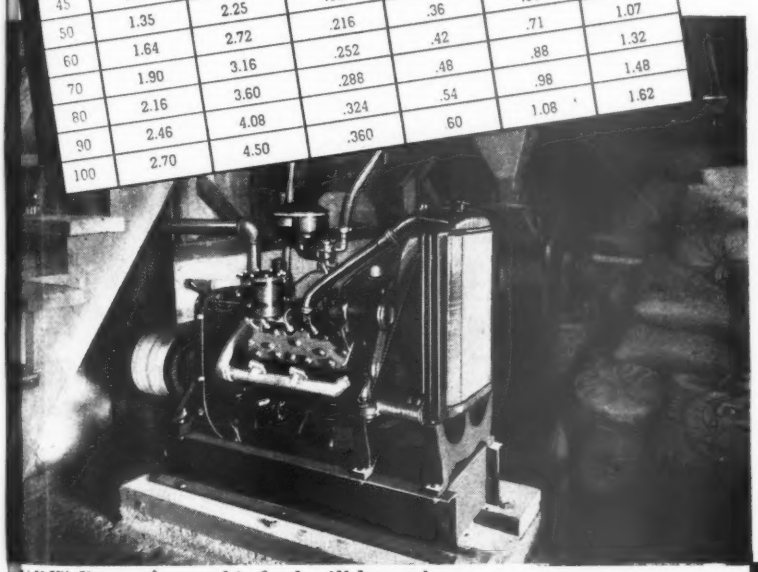
25	.68	1.13	.09	15	.30	45
30	.82	1.36	108	.18	.34	.51
35	.95	1.58	.126	.21	.39	.59
40	1.08	1.80	144	.24	.44	.66
45	1.23	2.04	.162	.27	.49	.74
50	1.35	2.25	.18	.30	.54	.81
60	1.64	2.72	.216	.36	.63	.95
70	1.90	3.16	.252	.42	.71	1.07
80	2.16	3.60	.288	.48	.88	1.32
90	2.46	4.08	.324	.54	.98	1.48
100	2.70	4.50	.360	60	1.08	1.62



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Pilot Plant Developments at Baton Rouge*

By E. V. MURPHREE, *President*, Standard Oil Development Company

We are here today to dedicate a new unit in the field of petroleum research—a research laboratory.

The laboratory has come to be one of the essential keys to human progress. It is the greenhouse in which ideas are nurtured and cultivated until they warrant larger-scale development leading to the huge plants and integrated processes that typify modern industry. It is here that ideas undergo the test-tube and small scale stages of development before they can be transplanted to the pilot plants and later to full-grown commercial units.

The research laboratory we are inaugurating today is another indication of the vast importance that the petroleum industry attaches to industrial research. In the Jersey group, for example, our research and development personnel has grown from 95 people in 1925 to about 2250 today. That is an increase of more than 2200 per cent. Accurate figures are not available to show the rate of increase in research and development for the petroleum industry as a whole, but it is probably close to that of the Jersey group.

The Esso Laboratories at Baton Rouge are among the great industrial laboratories of the nation. In your tour you will see for yourselves the complexity of a modern laboratory building. You will see its maze of hot and cold water pipes, high and low pressure steam, vacuum and compressed air lines. You will see the air conditioning needed both to protect the delicate equipment and to insure the comfort of the research workers. In addition you will see several large pilot plants.

But first I would like to give you a brief picture of the place the Esso Laboratories at Baton Rouge occupy in the research and development effort of the Jersey group. I want also to indicate a few of the accomplishments of the Baton Rouge Laboratories. I'd like to tell you particulary about their contributions to the more efficient use of oil products, thereby enabling supplies to be conserved for the future. I shall also outline some new projects that will extend supplies of oil products in the United States. Finally, I want to stress the importance of pilot plant work in industrial research and development.

Through Standard Oil Development Company the Jersey group operates or coordinates a number of industrial research laboratories. These laboratories engage in exploratory research, small-scale development, and pilot plant work. Of course different types of work receive different emphasis in the various laboratories. The Esso Laboratories at Baton Rouge constitute the main pilot plant center of the Jersey group. In fact, based on past accomplishments, they are without doubt the most important pilot plant center in the petroleum industry. Exploratory research and small-scale development also are carried on here, but the major emphasis is on pilot plant work.

A pilot plant reproduces the expected commercial plant in all essential features, but has a much lower capacity. It may have 1/100th or less of the capacity of the expected commercial plant. But the capacity of a pilot plant does not tell the whole story. A pilot plant able to produce but a "drop in the bucket" may be large enough to be mistaken for a full size plant. You will see a synthetic oil pilot plant here at Baton Rouge that produces less than 1/1000th of the amount of oil that a commercial plant would produce—less than 10 bbl per day. Yet it stands as high as a 12-story building.

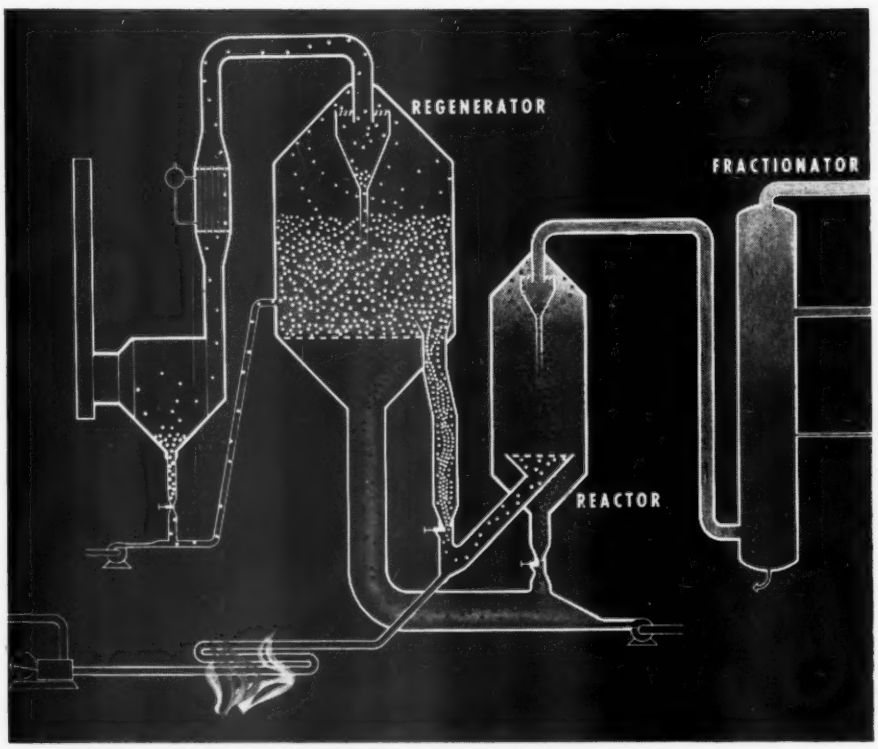
We are fortunate, indeed, that a plant of 10,000 bbl per day capacity would not have to be proportionately larger. After inspecting our pilot plant one visitor remarked, "I guess Texas is the only state big enough for your main plant because anywhere else you would be running into interstate commerce difficulties."

A pilot plant can be modified at relatively low cost until that particular design is obtained which gives the desired results. You might call it the bridge between the laboratory development of a process and its commercial application. Without this bridge a commercial plant costing millions of dollars to build might have to be redesigned at tremendous cost.

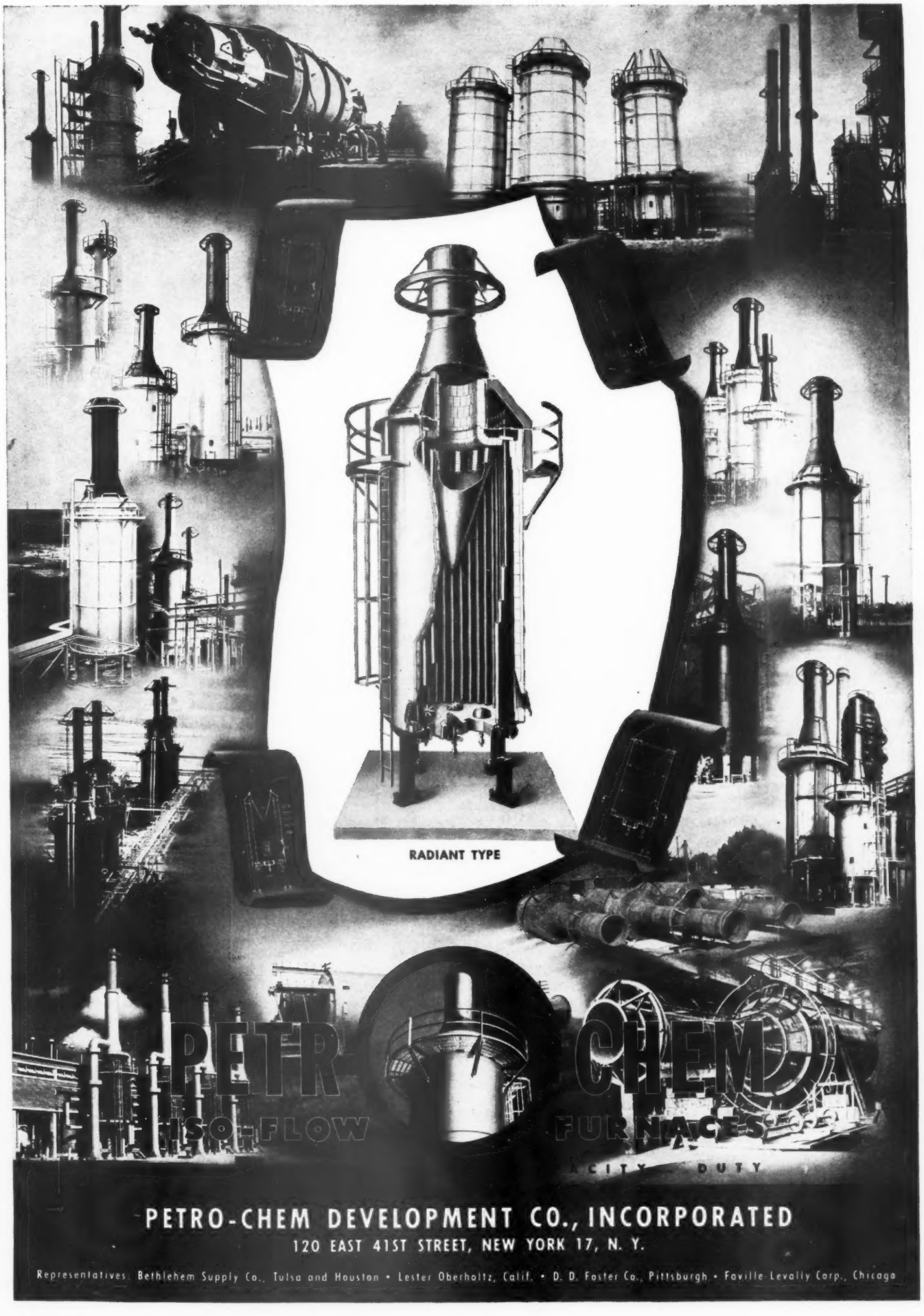
A good example of how importantly the pilot plants at Baton Rouge contributed to an outstanding scientific achievement is the development of what is known as the fluid catalyst technique. Catalysts, which, as you know, are substances used to speed up chemical reactions and influence the direction of the reactions, are finding ever greater application in petroleum processing. They are used in cracking to make gasoline from heavy oil, for making synthetic rubber for petroleum, and in converting

FIG. 1. Fluid catalytic cracking process.

—Photo courtesy Standard Oil Company (New Jersey)



*Paper presented at the dedication of the new laboratory building Esso Laboratories, Baton Rouge, Louisiana, January 12, 1948.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coal and natural gas into oil products.

The catalyst makes it possible to break up heavy oil at lower temperatures than otherwise would be required. It also influences the cracking reaction in such a way as to give us gasoline with much less tendency to knock.

In developing the catalytic cracking process the chief problem was how to handle a solid clay-like catalyst in the gaseous petroleum—how to mix them, separate them, and in general how best to circulate them through a cracking plant. A process was finally evolved that is known today as the fluidized solids technique.

The term "fluid" is applied to this type of catalytic cracking because the finely divided catalyst actually behaves like a fluid when aerated in a gas or vapor.

In the operation of the fluid catalytic cracking process (Fig. 1) preheated oil vapor produced by flash vaporization enters a reactor, carrying with it the catalytic material as a suspended dust. Because of the decreased velocity of vapors passing through the reactor, the suspended dust settles out to form a relatively dense, bubbling bed. Cracking proceeds in this bed at a temperature of about 900 F as the rising oil vapors contact the active solid, and is completed in about 20 seconds.

Product vapors then leave the bed and pass through a settling zone to a cyclone separator, carrying with them catalyst still in the form of a suspended powder. Here, a large part of this suspended powder is recovered and returned through a small standpipe to the catalyst bed.

The vapors — substantially catalyst free — proceed to a fractionator where they are separated into gas, high octane gasoline, heating oil, and gas oil fractions. A very small percentage of the catalyst escapes from the cyclone but is recovered as a heavy oil slurry at the bottom of the fractionator, from which it is pumped back into the reactor.

Meanwhile, the catalyst, separated from the cracked oil vapors, is withdrawn from the bottom of the reactor and discharged into an air stream, which carries it in suspended form to a regenerator vessel. Because of the decreased velocity of the carrying gas, another violently bubbling bed is formed in this vessel, and the carbon deposited on the catalyst during its passage through the reactor is burned off in the regenerator bed at a temperature of 1100 F. The purified catalyst is separated from the spent air, first in a settling zone above the bed and then in a cyclone separator, after which it is returned through a standpipe and control valve into the stream of hot oil vapor. At this point it begins a new journey into the reactor and a fresh cycle of operation.

The spent air leaving the cyclone passes through an electro-static precipitator, where the final traces of catalyst dust are recovered and returned in suspended form to the regenerator bed.

Remarkable results are produced by the violent action in the fluid catalyst beds. For example, in a plant-scale regenerator as much as 200,000,000 Btu's per hour may be liberated, yet the temperature in the regenerator seldom varies more than 5 F from top to bottom. This minor temperature variation, compared with the enormous heat liberation, is realized even though the seething catalyst bed may be 20 ft deep and up to 45 ft in diam.

Of particular interest is the fact that the complete cycle takes place without the use of a single mechanical moving part. It is the fluid condition of the catalyst that makes this possible. A pressure head is developed by the catalyst in the regenerator standpipe. This pressure is sufficient to cause the catalyst to flow from the regenerator, a zone of relatively low pressure, through the regenerator slide valve into the reactor, a zone of relatively higher pressure. The average particle of catalyst makes its way around the complete circuit every ten minutes, yet the process runs continuously for months on end.

A large-scale fluid catalytic cracking unit is capable of handling more than a million and a quarter tons of feed stock per year, or some 25,000 bbl per day. Such units are about 250 ft high — as lofty as a 20-story building—and contain more than 24 miles of piping, of which one section may reach 8 ft in diam. Some 40 tons of catalyst (as much as can be loaded into four railroad cars) are circulated through the unit every minute, yet the catalyst recovery is so complete that only 0.005 per cent of the 60,000 tons circulated daily is lost to the air.

Work on the development of the fluid catalytic cracking process started well before the war. A process was particularly needed for making higher octane number motor gasoline, and laboratory work had indicated that such gasoline could be produced by cracking with a catalyst. Indeed, a competitive group of companies had actually worked out one type of catalytic process that produced higher quality gasoline than could be made by non-catalytic methods.

The original research on catalytic cracking was carried out according to conventional methods of applying catalysts. That is, the catalyst was used in the form of granular particles in a fixed bed. But a complication arose due to the fact that in the cracking reaction carbon is deposited on the catalyst. The carbon deactivates the catalyst and must be burned off. This regeneration of the catalyst in a fixed bed involved many practical difficulties.

Investigation began of the possibilities of using catalyst as a powder that could be carried through the reactor as a dilute suspension in the oil vapor to be cracked. The used catalyst then could be passed in a continuous operation through a regenerator where the carbon could be burned off. The laboratory development of this process looked quite promising and it was put into pilot plant operation. Here a number of undesirable features came to light that would have made commercial application difficult.

At about this time investigations we had sponsored at the Massachusetts Institute of Technology suggested a possible solution. They indicated that if a very concentrated suspension of finely powdered catalyst were properly handled, it could be kept in a very fluid-like, freely-flowing condition in what since has been termed a fluid bed.

We had also discovered that by regulating the density of the catalyst suspension, this finely powdered catalyst could be circulated between two vessels at very high rates without the use of any mechanical moving parts in the equipment. Our catalytic cracking pilot plant was rapidly modified to incorporate these features, and from that point on the outlook improved.

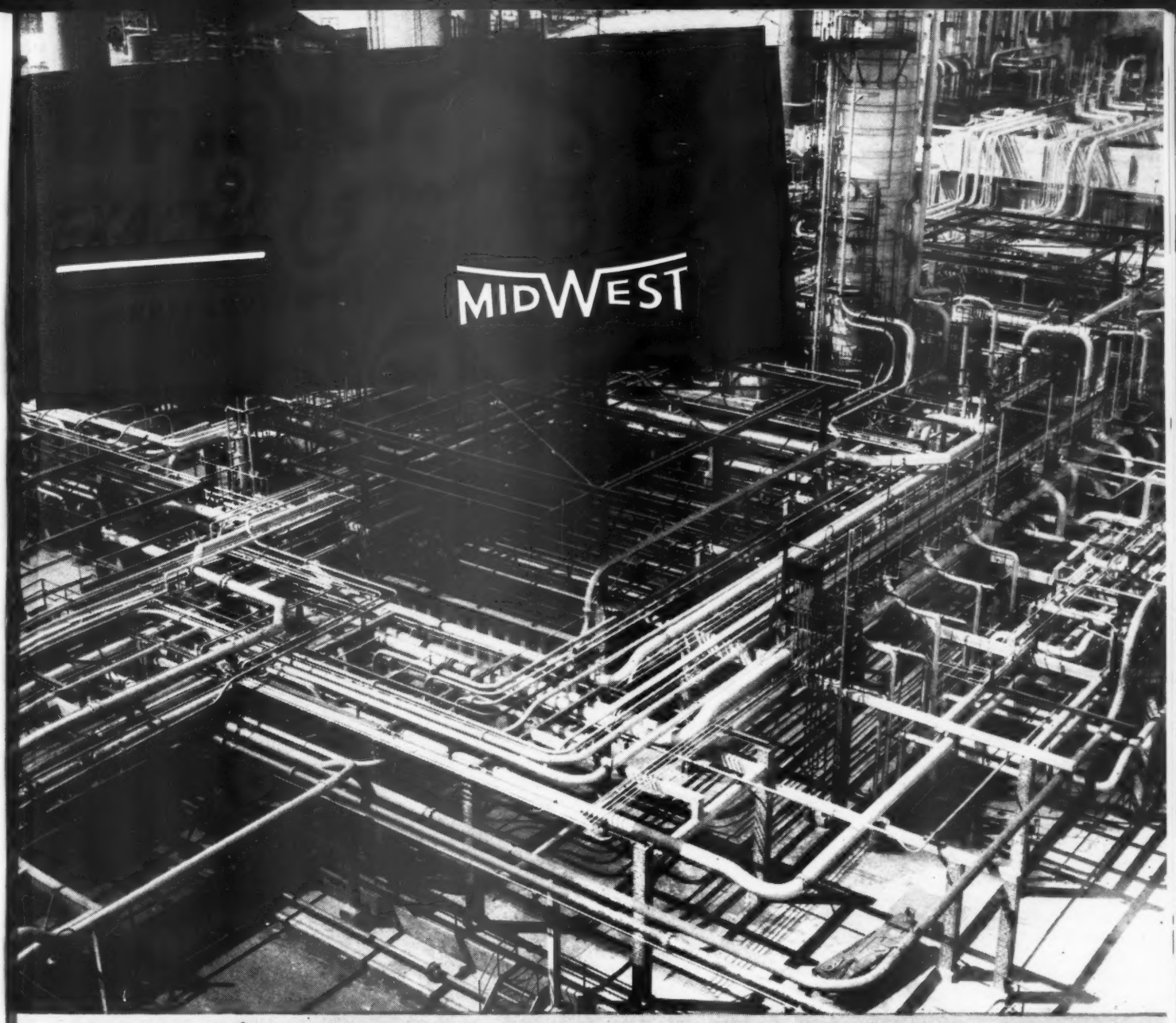
We were just beginning to obtain engineering and operating data, together with experience in operating the plant, when the war came. At once the need became urgent for large quantities of raw materials for 100-octane aviation gasoline and synthetic rubber. The oil industry felt that the fluid catalytic cracking process offered the best prospect of producing these materials in the quantities desired, even though the process had not been operated commercially. It was accepted solely on the basis of pilot plant operation.

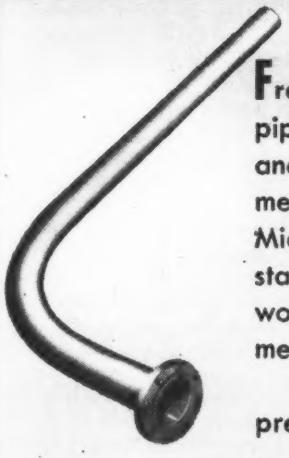
The rapid wartime application of the fluid catalytic cracking process without any commercial operating background put a terrific responsibility on all of those concerned with its development, and particularly on the Baton Rouge Laboratories. An investment of more than one billion dollars was involved, and that was a serious matter indeed. But far more serious than that was the fact that the success of the whole war effort depended to a considerable degree on the successful operation of plants under construction.

As one of those immediately concerned with this project, I can say that we were all deeply conscious of the great responsibility placed upon us. In fact, we were all scared to death. Fortunately, the pilot plant work had been carried out with such skill that the process functioned without a hitch from the moment it went on stream.

Immense strides have been taken since that day. At the present time, the combined capacity of fluid catalytic cracking plants installed or under construction is about 1,200,000 bbl per day representing some 62 units. Today fluid catalytic cracking has a very important peacetime significance. It makes possible the production of gasoline in higher yield from crude oil than the thermal cracking process it displaces. And the gasoline produced is of much higher octane number, which means that it has less tendency to knock.

While the gasoline yield advantage of catalytic cracking is important, the potential conservation of our oil supplies through more efficient fuels is of far greater importance. Gasoline produced by the fluid catalytic cracking process has a Research Octane Number of about 100 when tetra-ethyl lead is added. This fuel will meet the requirements of a 10 to 1 compression ratio engine. In cars





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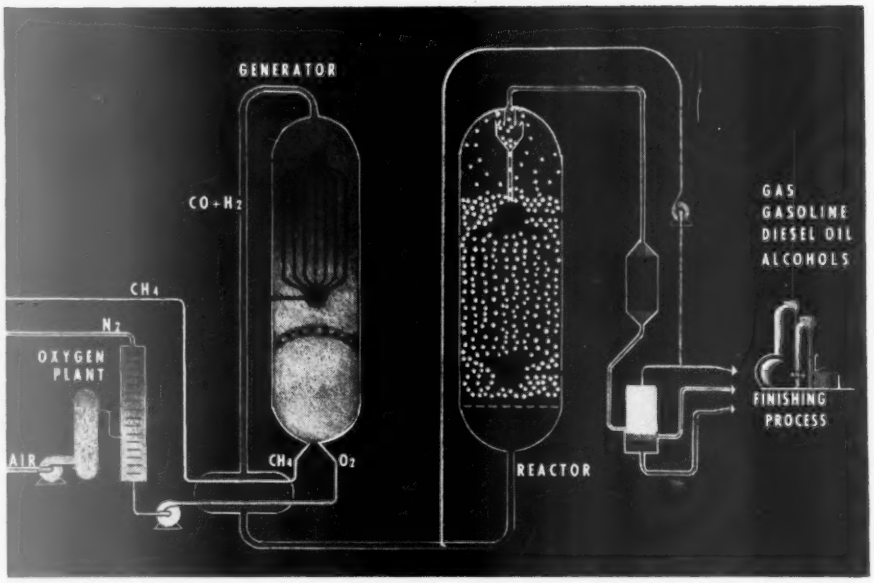

FIG. 2. Hydrocarbon synthesis process. —*Photo courtesy Standard Oil Company (New Jersey)*

having comparable acceleration, hill climbing ability and other performance features, such an engine is capable of giving 30 per cent more miles per gallon than our present engines of about 6.6 compression ratio. When used in cars properly designed to take advantage of its high quality, the gasoline produced by catalytic cracking therefore makes possible a decided saving in fuel consumption.

The fluidized solids technique should have applications in many fields of modern industry. One of its first extensions has been in the development of processes for the production of synthetic liquid fuels from natural gas or coal. The importance of such a development may readily be seen when the apparent extent of our crude oil resources is considered in terms of the demand that we may have to meet in the future.

On a world basis, existing reserves of crude oil, together with anticipated new discoveries and extensions in known fields, should meet the expected demands for many years. This assumes free availability of world supplies.

In the United States, however, it is doubtful that proved reserves plus new discoveries and extensions of existing fields will be adequate for meeting domestic demands. This country in time will become increasingly dependent on imported oil. Higher costs of finding and producing crude oil, together with added transportation costs for imported crude, all contribute to making the production of synthetic fuels more favorable from an economic standpoint. Also, production of such fuels may have importance from the standpoint of national defense.

The known reserves of natural gas in the United States are about 160 trillion cu ft. Based on presently known efficiencies of conservation, these gas reserves would yield 13 billion bbl of synthetic oil products, mainly gasoline. In potential oil products, our known gas reserves are therefore equivalent to about 62 per cent of our proved crude oil reserves.

After making allowances for a continuing supply of gas for heating and other purposes, it is estimated that some 300,000 to 500,000 bbl per day of synthetic oil products might be produced from natural gas. Two commercial plants with an aggregate capacity of 14,000 bbl per day of synthetic oil are now being constructed. Under today's conditions, the cost of synthesizing oil products from natural gas is competitive with production from crude oil.

The United States reserves of coal have been estimated at 3.2 trillion tons. We could allow adequate reserves for existing needs and still have sufficient coal, if it were converted to oil, to meet all the oil requirements of the United States for at least 1000 years.

Unfortunately, production of oil from coal involves a very high investment per unit of capacity and rather high manufacturing costs. Therefore, it probably will not have economic application for some years to come; but even so, the added cost of making gasoline from coal would probably, for the average motorist, not amount to more than 10 to 15 cents per day.

At the present time in the United States, synthesis from natural gas is closer to plant-scale application than synthesis from coal. A representative technique for the production of synthetic hydrocarbons from natural gas is illustrated in Fig. 2.

After preheating in a heat exchanger to a temperature of about 930 F the natural gas, principally methane (CH_4), is fed into a synthesis gas generator, together with similarly preheated, compressed oxygen. The burning zone of the generator is an open chamber lined with refractory insulation, and here the methane is converted by partial oxidation to carbon monoxide and hydrogen. The temperature level in the combustion zone is about 2450 F and the pressure 20 to 30 atmospheres.

On leaving the combustion zone, the hot products of combustion are cooled, first in a waste heat boiler in the generator and then by heat exchange with incoming methane and oxygen. The gas now enters at the base of a fluid type reactor operating at about 660 F and a pressure of 20 to 30 atmospheres. Here, in the presence of an iron catalyst, which, in "fluid" state, is in constant and violent motion, it reacts to form synthetic hydrocarbons and water.

The reaction liberates a very large amount of heat, amounting to nearly 14,000,000 Btu's per ton of liquid produced. But high rates of heat transfer through cooling tubes immersed in the fluidized catalyst permit the maintenance of uniform temperature throughout the catalyst. The heat of the reaction is absorbed in the vaporization of water to form high pressure steam, which is a source of heat and power throughout the plant.

In the past, the major difficulty in applying the synthesis operation to large-scale production has been the maintenance of an even catalyst temperature despite this large heat evolution, for a relatively deep bed of catalyst is employed in the synthesis reactor. However, this difficulty has been solved as efficiently as in the case of the fluid catalytic cracking process.

The synthesis product leaving the fluid bed in vapor form carries with it a small amount of entrained catalyst. This is recovered in a cyclone and returned through a dip pipe to the catalyst bed. The vapors leave the reactor to be cooled in a condenser and pass from there into a separator where the liquids are separated from the gases, some of which are recycled for further processing. The liquid products—high octane gasoline, diesel oil, and chemicals—then undergo normal finishing treatment.

The importance of the fluidized solids technique in solving the problem of our future oil needs is that it greatly simplifies the production of synthetic fuels from coal and natural gas and thereby reduces the cost.

It is interesting to compare this process with the one used in Europe. Due to the even temperature of the fluidized catalyst bed and the high rates at which heat can be extracted from it, it is possible in a plant of 10,000 bbl per day capacity to reduce the number of reactors from 128 to 4. Also, the cooling surface can be cut from about 6,000,000 sq ft to 20,000 sq ft. Furthermore, the use of an iron catalyst instead of the cobalt catalyst used in Europe allows production of a much higher octane number gasoline.

Another application of the fluidized solids technique is in the processing of shale. Very substantial reserves of reasonably rich oil shale exist in the United States, particularly in the Rocky Mountain area. It has been estimated that more than 75 billion bbl of oil, or 360 per cent of known United States crude

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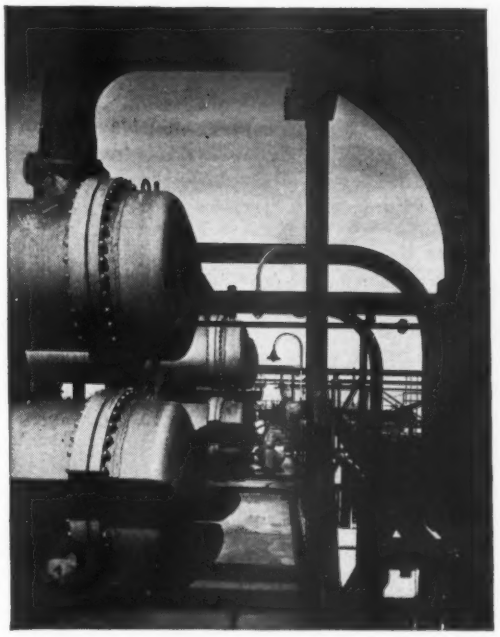

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THE "master" type of contract for refinery modernization and expansion—under which one engineering company takes complete responsibility for all work—nowhere manifests its superiority to greater advantage than in the time-consuming details of mechanical engineering.

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To get down to a few specifics in the matter of savings through coordination, the "master" contract operation saves time *at the very inception of mechanical engineering*—in the initial problems concerned with the relative locations of the process units, their space and tankage requirements and such provision for future expansion as may be deemed necessary without undue initial investment. The required off-site facilities are usually an important factor in these problems and therefore simultaneous studies must be made of the electric power, steam, fuel gas, water and air distribution systems, all yard oil piping and the various sewers and blowdown systems, before an intelligent decision can be made.

Detailed design of the process units cannot be started until this overall picture has been completed, steam, water and fuel gas pressures and temperatures at the battery limits have been determined, where all incoming and outgoing services and oil and sewer lines should enter and leave each battery limit and their elevations.

All these as well as a veritable host of other important engineering details *must be* integrated between units—not on the basis of greatest ease or economy in the building of any one unit—but on the basis of *overall economy and efficiency of the entire processing plant.*

To obtain such integration to the maximum degree of final efficiency among the various design departments of several engineer-contractors is obviously expecting the impossible from human nature. For it must be borne in mind that each engineer-contractor has developed his organization along lines that suit his particular method of operation. Each has his own particular methods and standards of design, each his own table of specifications. If the impossible is accomplished, it is *still* costly—for since each contractor must wait for information from the other there is time consumed in its accomplishment that could serve either to advance the date of operation of the unit, or lower its cost, or both.

There is still another major overall advantage of the "master" contract operation—beyond the actual dollars-and-cents savings in engineering time. This is in the *uniformity of engineering specifications*—when all work at the job site is handled by *one concern.* Such uniformity results in reduced construction costs since all buildings and structures will be of uniform basic design. Furthermore, such uniformity results in reduced maintenance costs and a smaller spare parts inventory, neither being an inconsequential consideration in these days when maintenance costs are a major factor in establishing processing profits.

by
O. G. PRATT
In Charge of Mechanical Engineering
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oil reserves, could be obtained from shale deposits in this country that appear rich enough to warrant processing.

The cost of mining oil shale is a major item. It is likely, however, that a number of large shale deposits could be worked to yield oil products at somewhat lower cost than that of producing oil from coal.

The initial step in the processing of oil shale is to heat it to 900 to 1000 F. This causes the organic matter in the shale to break down into what is essentially a synthetic crude oil. This oil then can be processed to yield various products.

The heating of the oil shale, known as retorting, has offered considerable technical difficulties due to the tendency of many shales to swell and cake. For these difficulties the fluidized solids technique appears to offer a solution.

Crushed, fresh shale would thereby be fed continuously into a hot, fluidized bed of previously retorted shale. Through the intimate mixing of the fresh shale with the hot retorted shale in the fluidized bed, the retorting of any particular shale particle would be almost instantaneous, and at no time would there be a high concentration of unretorted shale in the bed.

The retorting of shale through the fluidized solids technique can be performed with either one or two vessels, depending on which of two heating methods is used.

In the one-vessel system, (Fig. 3) air is blown directly into the bottom of the retorting vessel, and heat is obtained by burning a small amount of the shale. The products of retorting, together with the flue gas produced, are passed to recovery equipment. This method has a disadvantage in that the flue gas is mixed with the products and recovery of the low boiling products is complicated and expensive. Also, the burning of some of the shale reduces the yields.

In the two-vessel system, air is not blown into the retorting vessel. Instead, a small amount of steam is used to keep the solids in a fluid state. Heat is generated by burning retorted shale, which still contains some organic matter, in the second vessel.

Hot solids from this vessel are circulated back to the first vessel, where the retorting takes place and the products are recovered. Because they are not mixed with the flue gas, recovery is simplified. Spent shale is discarded from the second vessel.

The single-vessel method of shale retorting has been well demonstrated on a small pilot plant scale. We plan to carry out a large pilot plant demonstration of the two-vessel system of shale retorting at the Baton Rouge Esso Laboratories. Shale for this operation will be provided by the Bureau of Mines from the extensive Navy oil shale reserve in Colorado. This demonstration should put the retorting of oil shale on a more economic basis and bring nearer the utilization of a vast and as yet unexploited source of oil products.

Development of the fluidized solids technique is but one illustration of the importance of pilot plants. They have been equally significant in countless other developments. At least one of those deserves special mention. When the country was cut off from its rubber supplies early in the war, we had no commercial method for making synthetic rubber for tires. Laboratory work indicated that petroleum could serve as a raw material through a catalytic dehydrogenation process, provided the process could be carried out commercially. Based on data obtained from rapidly carried-out pilot plant tests, the first full-scale dehydrogenation plant was designed and constructed here at Baton Rouge. When that plant went on stream on May 21, 1943, we all held our breaths. The nation's synthetic rubber supply depended to a considerable degree on the success of its operation. It simply had to work. It did work, and during the war the dehydrogenation process made available three-quarters of all the synthetic rubber produced from petroleum in this country.

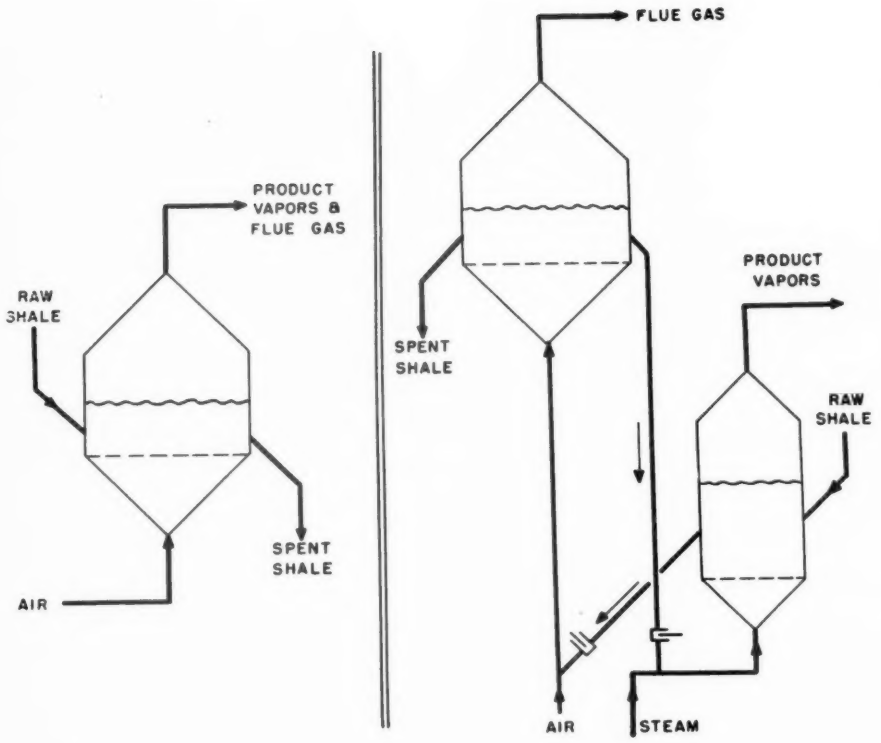

FIG. 3. Single-vessel and two-vessel techniques for shale retorting.

These are just a few examples of vital pilot plant developments that have been conducted in the Esso Laboratories at Baton Rouge. There are many more. The laboratories have also carried out extensive pilot plant programs involving hydrogenation of oil, manufacture of chemicals, and a variety of petroleum-treating operations.

You will have shortly an opportunity to see some of the equipment in the laboratories here. During your tour I would like for you to bear in mind not only that the Esso Laboratories at Baton Rouge are the major pilot plant center for the Jersey group of companies, but that many of the most important pilot plant developments in the petroleum industry have been carried out at this location.

I have tried to give you some idea of the importance of pilot plant work and have pointed out that it is the bridge between laboratory development and industrial application. Among the many pilot plant developments at Baton Rouge, I have touched particularly on two. One is the fluid catalytic cracking process, which produces a gasoline capable of giving greater economy in cars built to use it. The other is a process for making synthetic fuels from natural gas or coal. You will see pilot plants for both of these operations today. I have outlined a development soon to be initiated at the laboratories to augment even further our supplies of oil products by extracting a synthetic crude oil from oil shale.

What you will see is a small segment of a vast integrated industry, whose success depends on the teamwork of many thousands of men engaged in different jobs. In the Baton Rouge Laboratories the jobs performed come under the broad heading of research and development.

Research and development are not commodities that can be bought with mere dollars. They succeed only through the technical sweat of well-trained, competent, imaginative scientists and their skilled assistants who know the problems requiring solution and who have the laboratories and other facilities needed to solve them.

The laboratory we are dedicating here today represents another step forward in our constant endeavor to give our men the tools they need to do the job.

★ ★ ★

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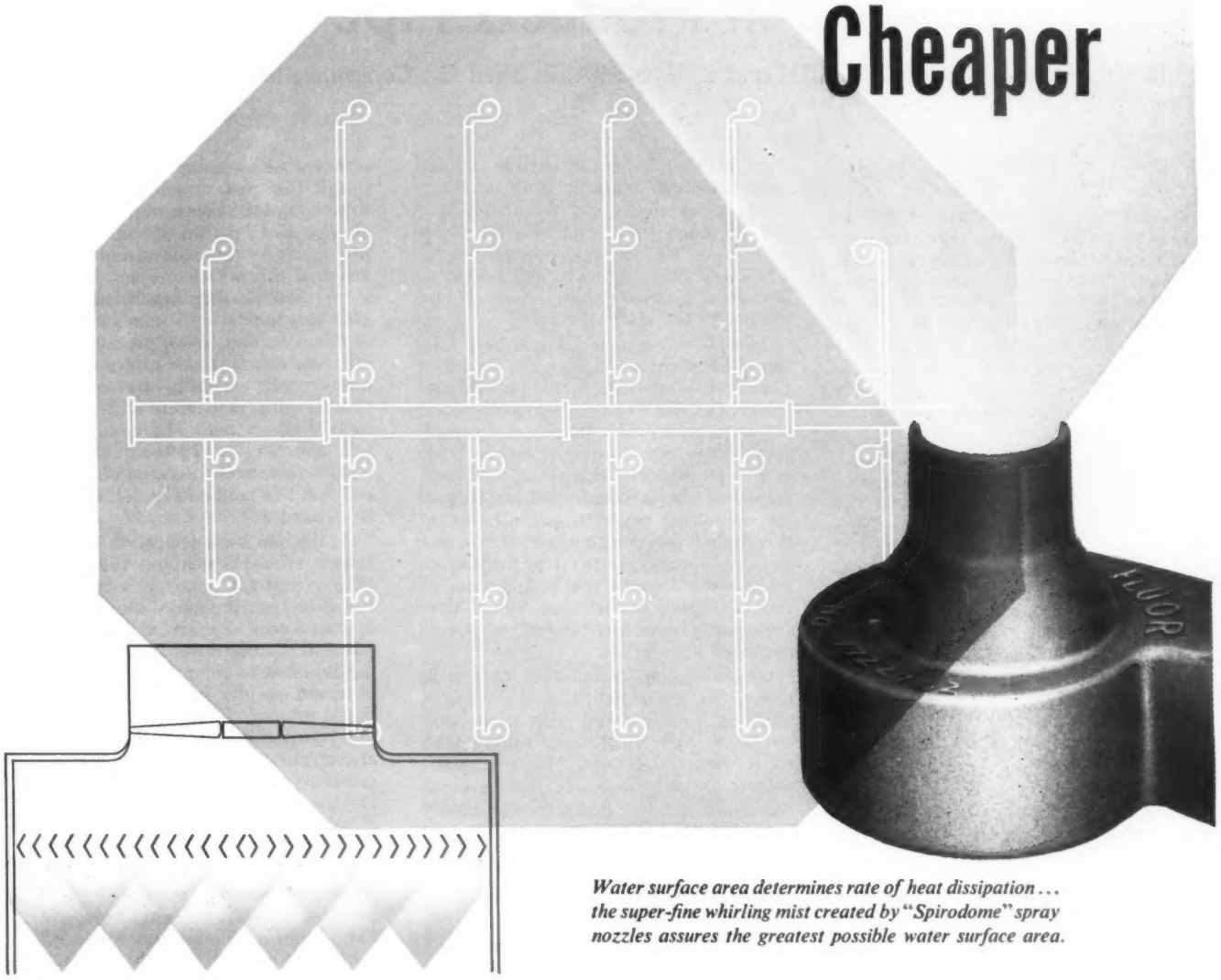


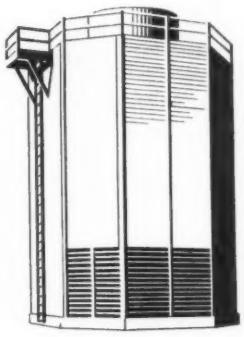
Water surface area determines rate of heat dissipation... the super-fine whirling mist created by "Spirodome" spray nozzles assures the greatest possible water surface area.

Cheaper? Yes, and here's why: The upspray distributing system in the Fluor "Counterflo" induced draft cooling tower, which incorporates the patented "Spirodome" Spray Nozzles, adds 8 or 9 feet of *unseen* cooling tower height. Here's how:

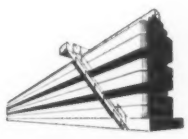
Water is sprayed 6 to 8 feet up into a spray chamber, where the drops are broken up into minute particles, and where the great heat load is flashed off before the drops even reach the first deck. Therefore the function of the decking is not to release the great bulk of the heat, but rather to cool the water to as close to wet bulb temperature as possible.

This system is a "must" where hot water is to be cooled, since the upper portion of the tower is at least twice as effective as the same tower with the usual flume and splash plate system.

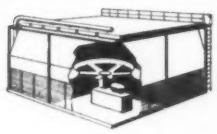
Yes...Fifty years' experience proves Fluor Cooling Towers will, year in and year out, deliver colder water cheaper.



Fluor "Counterflo" induced draft cooling towers, prefabricated in mass production, are available in multiple or single units in any required size or height.



Fluor areator atmospheric cooling towers are recommended where conditions make this type most practical.



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Interfacial Mixing Characteristics of Products in Products Pipe Lines*

By S. S. SMITH and R. K. SCHULZE, Shell Oil Company, Inc.

PART I

An audience of petroleum engineers needs no briefing on products pipe lines and their present place in the petroleum business. Neither will this audience need to be told of the many new features of engineering and design that have gone into the making of modern tight line operation as compared to the conventional float tank station design that was pretty much current in crude lines a few years ago.

It may be that the studies made to determine mixing rates between successive batches of different products and the means used to protect product specifications to close limits may be of interest, however, and may even point the way to further improvements in practice. So this paper will concern itself with laboratory exploration of the mixing characteristics of products flowing in pipe lines and methods used in field practice as a result of laboratory experimental work.

Logically, we should go back to the state of the art when this work was initiated. At this time, we in Shell Oil Company had no experience in products pipelining, and only superficial knowledge of the work that other companies, starting earlier than we, had accomplished. So, as it were, we started with a clean slate, but with a general knowledge of pilot plant work that had been done in other industries such as the natural gasoline refining and cracking, chemical synthesis, etc. We knew therefore that properly handled pilot plants would predict full-scale commercial operations cheaply, quickly, and with good accuracy, if reasonably tied to known factors of full-scale operation.

In an ideal set-up we should have done our pilot plant work first and designed from the pilot plant data, but, as frequently happens in commercial ventures, we were projected into actual construction before our operating organization was selected, and therefore field construction, the selection and training of an operating organization, studies of theoretical operating considerations, and the development of operating techniques all proceeded concurrently, and much of the laboratory work came along after some sort of confirmatory field work had preceded it.

A description of the laboratory is in order. We inherited a 20-ft by 90 ft building, and our first pilot plant consisted of 5000 ft of Saran tubing with an approximate ID of 0.6 in., strung circularly around the inside roof eaves of this building. The pumping equipment consisted of a Westco pump connected through a Link Belt variable speed drive to an explosion-proof motor of 10 hp. The Link Belt drive provided a continuously variable speed of 600 to 3600 rpm at the pump. The pipe was laid as a continuous system in closed cycle so that repeated circuits could be made with the same batches of product. Measurement was accomplished with a Pittsburgh 1-in. piston meter, carefully calibrated, and the measurement of product change was a matter of considerable experiment. As this measurement was the heart of this whole project, it deserves more than passing attention. The first plan was to provide a number of lengths of Pyrex tubing, using products dyed in different colors in the line, and to interpret results visually by color. This proved quite inaccurate and was immediately abandoned. The next effort was to interpret colors by their relative light transmission recorded on a photoelectric cell, but this method also fell short of desired accuracy.

At this point we decided there were no known available methods that could be used except the commercially available recording gravitometers which, however, operated on a slip stream from the main line and therefore would add to the mixing inherent to our pilot line and distort observed results because of this additional mixing. Hand drawn samples of the passing stream were ruled out as also apt to distort the true picture by removing portions of the mixed product, and thereby reduce the apparent volume of mixture.

So we ourselves designed a full stream gravitometer, to weigh the whole of the passing stream. This design was the work of one of our engineers, Norris Plank, and as the success of the whole project is almost entirely due to this apparatus, it merits description. The primary element is a single loop of the same pipe that makes up the mile long circuit. This loop is supported on a drum, the drum in turn floated in a water bath and weighted with water to just balance the product in the pipe line. The floating drum is connected to the beam and lever mechanism of a Toledo scale, which converts any vertical motion of the floating coil because of gravity change into lateral movement of a pin arm impinging on a continuously moving strip chart. The range of the instrument is readily adjustable to render a full-scale spread regardless of gravity of the two or more products under test. Its accuracy is sufficient to accurately differentiate between products having specific gravity difference of only 0.001. As the gravitometer weighs the whole stream with no diversion of a portion of the stream, the instrument itself neither adds to nor subtracts from the mixing of products in the pipe line itself. This apparatus for a 2-in. line is illustrated in Figs. 1, 2, and 3.

The gravitometer served a second useful purpose. As each cycle of the pipe line was finished, the gravitometer gave

*Presented before Petroleum Division, American Institute of Mining and Metallurgical Engineers, at Tulsa, Oklahoma, October 8-10, and at Los Angeles, California, October 23-24, 1947.

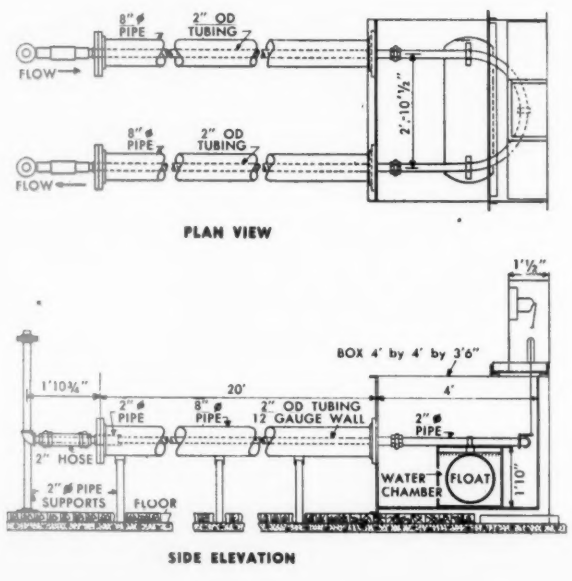


FIG. 1. Two-inch gravitometer experimental pipe line laboratory of Shell Oil Company at East Chicago, Indiana.

us an accurate "flag" of the pumping of the full pipe line volume, and therefore served as a constant calibration check of the meter measurement. Thus the volume determination of the mixture between adjacent products could be kept at an absolute standard of accuracy, regardless of temperature, pressure, flow rate, or viscosity without disturbing the continuous cycle operation of the whole unit.

It is well known that measurements of flow characteristics of fluids derived from pipes of extremely small diameter are not too reliable an index of operations in large diameter lines, and until we could check this diameter factor carefully we could not be sure of anything but qualitative answers from experiments. Therefore, after a relatively few runs in the Saran tubing line, we decided we should more nearly approximate actual field pipe lines, and we therefore constructed a new system of standard 2-in. welded line pipe, 5000 ft in length and with new and larger pumping equipment, meter and gravitometer. Into this system went minor refinements in pumping and piping design, and included in the design was the necessary valving and long radius fittings so that scrapers could be dispatched through the line as an additional means of studying product separation. This whole apparatus is shown in Figs. 4, 5, 6, and 7.

With this 2-in. line we could operate at velocities that gave us Reynolds Numbers up to nearly 200,000, and we were reasonably sure that information derived from the 2-in. line would be possible of accurate comparison to lines of 6-in. and larger diameters. The 2-in. line pumping equipment consisted of two National Transit rotary pumps placed 2500 ft apart in the 5000-ft line. They were operated by explosion-proof motors driving through Speedmaster variable speed drives that gave the pumps operating speeds of 600 to 3600 rpm. The pumps were installed across a very short bypass built around Merco Nordstrom plug cocks so that during scraper runs the line could be kept in continuous operation by using alternate pumps. An indicating device was installed in the line to show passage of the scraper at a reference point. This device operated a two-way switch lighting alternate lights as an indication to the operator that he should switch pumps and bypasses. Metering was accomplished by a 2-in. Pittsburgh rotocycle meter carefully calibrated for rate and product on the individual operation. Connected to the system was a "tank farm" of three tanks, each capable of holding something over the 21 bbl required to fill the line, with connections arranged so that the line fill could be made up or bled while the line was in operation. Suitable pressure gauges, thermometer wells, etc., were provided in the system so that complete data were obtained on each run. This line was constructed of steel pipe and, aside from its 2-in. diam., equivalent in every way to field construction. When first operated, it developed the same problems of internal scale formation as our commercial lines. We permitted this scale formation deliberately and then inhibited and scraped the line, thus removing the mill scale just as we did in commercial practice. Once done, the line was operated under inhibitor control, and C factors were regularly checked to determine that there were no significant changes. We also, to insure the same accuracy of results on all runs, made repeat runs at identical velocities on standard products from time to time.

These rechecks assured us that the line was maintained in standard condition, so we could be certain that the work done at the latter end of our experiments represented physical conditions on the line, duplicating earlier tests.

The obvious intent of these installations was to provide a means of producing in miniature any operating condition of temperature, flow, product, viscosity, etc., that might obtain in a field operation, and to have such complete control of the operation at all times that

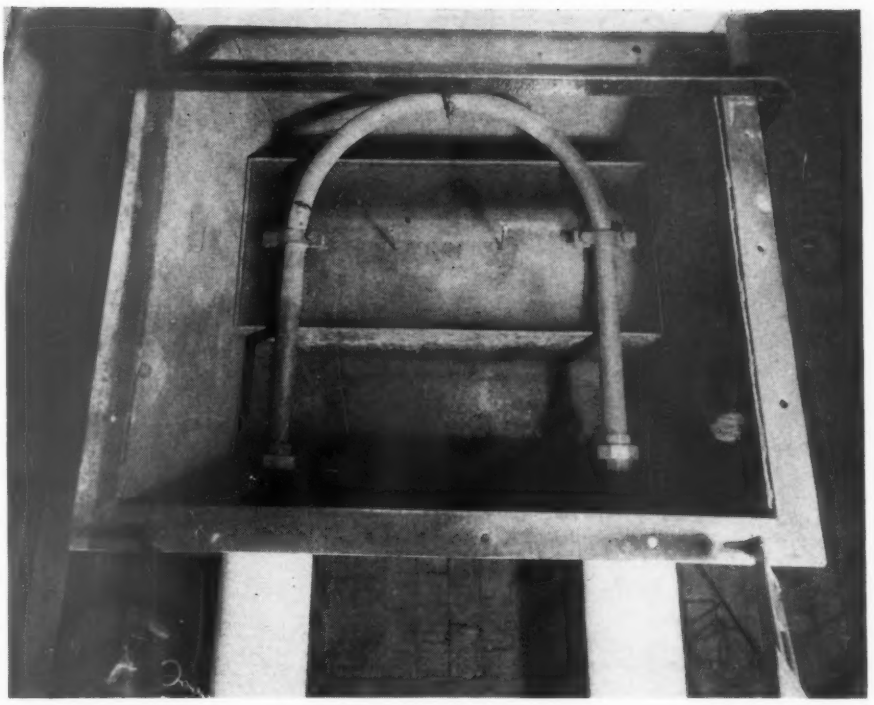
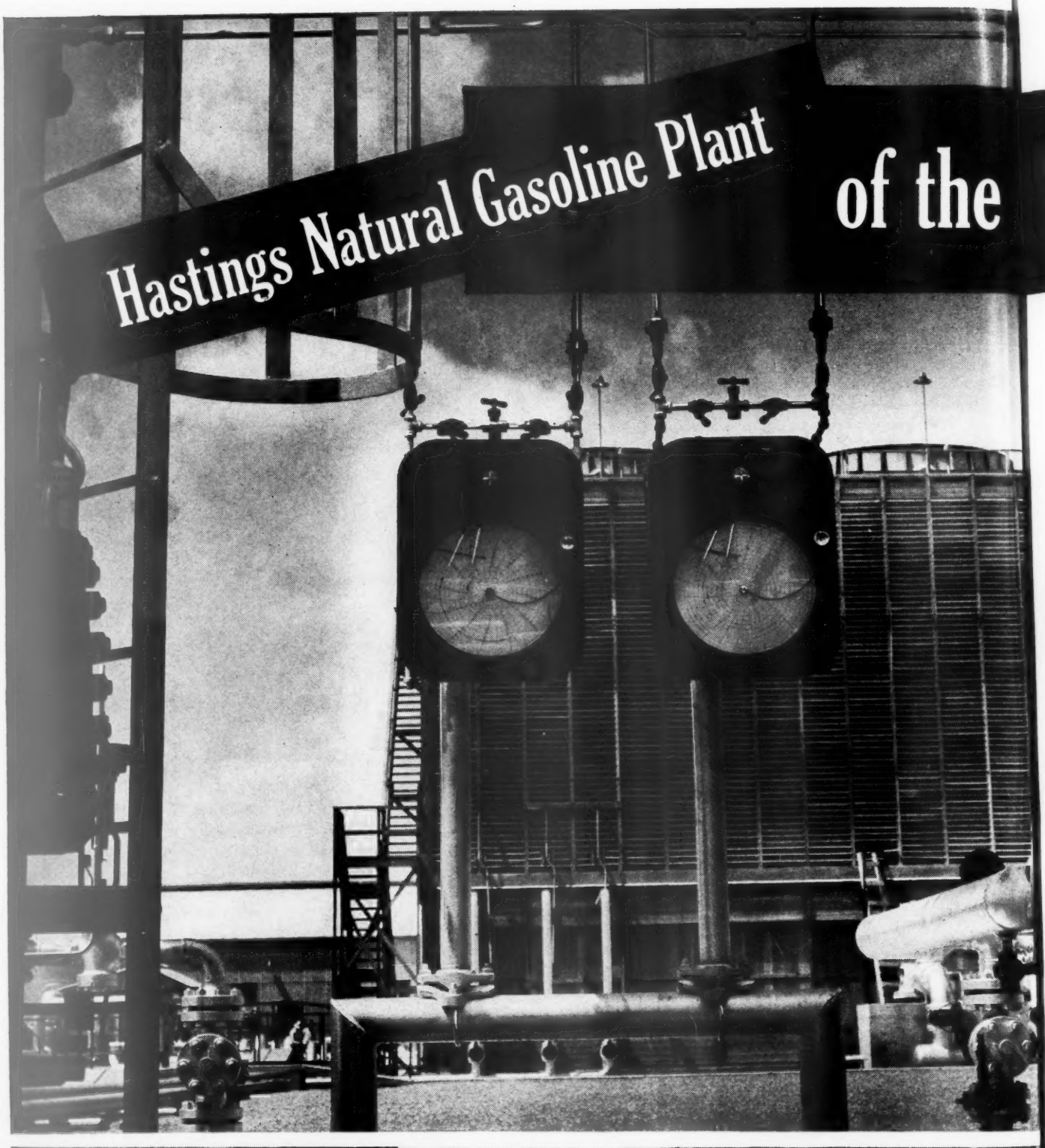
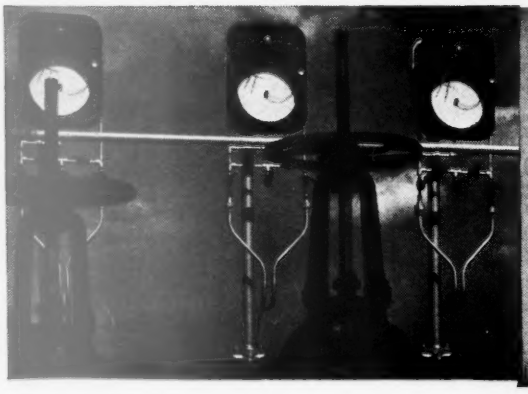


FIG. 2. Interior of gravitometer water bath chamber with recording instrument removed, showing "U" bend of gravitometer piping and float.

FIG. 3. Gravitometer water bath chamber and recording instrument.

Hastings Natural Gasoline Plant of the St

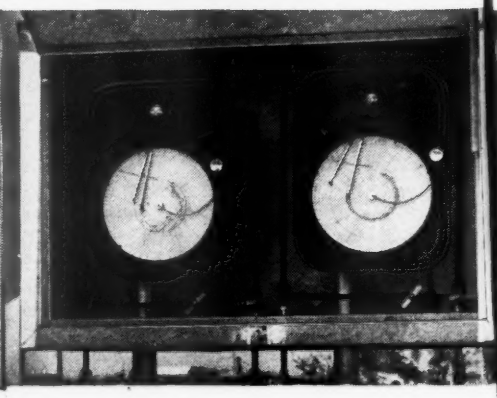




TOP: Dry gas overhead from absorbers

LEFT: Ahead of Compression. Three field mains equipped with Metric Orifice Meters deliver into a header

RIGHT: Twin Metric Orifice Meters on a Hastings lease. One for measuring wet gas from field gathering system, the other for dry gas used in field operations



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Metric Orifice Meters are effectively serving the exacting requirements of this plant at Hastings. The California Company's Lake St. John and Cranfield Plants; Shell's Sheridan Plant; Humble's Katy, Tom O'Connor, Anahauc, Clear Lake Plants, and others are demonstrating the suitability of Metric Orifice Meters for high pressure applications up to 5,000 P.S.I.

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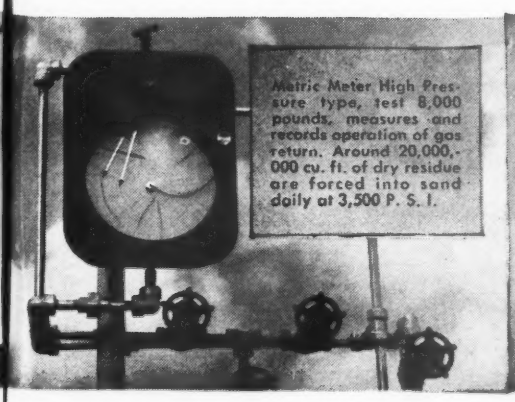
Metric Meter High Pressure type, test 8,000 pounds, measures and records operation of gas return. Around 20,000,000 cu. ft. of dry residue are forced into sand daily at 3,500 P. S. I.

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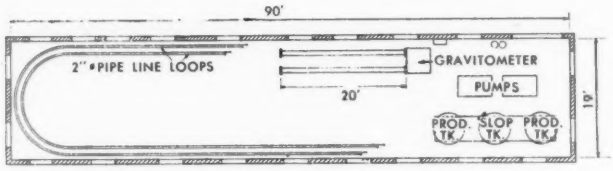
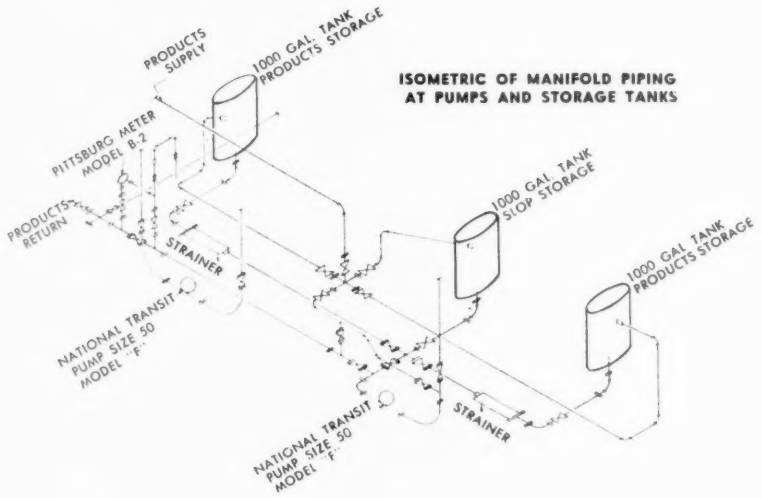
FIG. 4. General layout of laboratory and arrangement of piping, pumps, and storage tanks.



PLOT PLAN 2" EXPERIMENTAL PIPE LINE LABORATORY


ISOMETRIC OF MANIFOLD PIPING AT PUMPS AND STORAGE TANKS
PRODUCTS SUPPLY
1000 GAL. TANK PRODUCTS STORAGE
PITTSBURG METER MODEL B-2
PRODUCTS RETURN
STRAINER
NATIONAL TRANSIT PUMP SIZE 50 MODEL "F"
1000 GAL TANK SLOP STORAGE
1000 GAL TANK PRODUCTS STORAGE
STRAINER
NATIONAL TRANSIT PUMP SIZE 50 MODEL "F"

none of the normal commercial restrictions that hinder or prevent collection of accurate and complete data in the field would exist, and to have it all at fingertip for the laboratory technician. Work on actual collection of data was well under way in 1943 and was actively continued for more than two years.

Experimental runs were laid out to cover the normal liquids handled in product lines, and the pumping and recording equipment was arranged to handle about the same range of velocities and Reynolds Numbers found in commercial installations. As a broad research of this sort involves a lot of wasted effort and a large collection of figures and data, no effort will be made to describe each of the runs. Broadly described they covered propane, butane, gasolines, kerosines, and fuel oils. Velocities ranged from 0.44 ft per sec to 7.16 ft per sec with Reynolds Numbers all the way from 500 to 195,500. Length of runs varied with operating conditions of flow and viscosities from 50,000 ft up to 300,000 ft, usually being stopped by the fact that mixing had spread to the full length of the product or somewhere near half the length of the line. Viscosities from that of propane about 0.2 kinematic to that of No. 5 fuel oil about 48 kinematic were used. In each series of runs on a pair of products we endeavored to find the lowest velocity that would support commercially economic operation and also to evaluate the higher velocities into a comprehensive collection of data that could provide the basis for either a generic formula for mixing in pipe lines, or relate length of run, velocity, and a product index to provide design data for any pipe line problem. So far, more than 250 runs have been made on the 0.6-in. diam and the 2-in. diam lines, with complete data recorded on each run.

Fig. 8 shows one of the typical mixture runs on two grades of gasoline, having specific gravities of 0.7358 and 0.7226. Their respective Reynolds Numbers at 5.03 ft per sec velocity were 111,000 and 123,900 and the Reynolds Number of the 50/50 mix was 121,800 by laboratory determination of kinematic viscosity. This run was at relatively high velocity and Reynolds Numbers and gravitometer charts are here reproduced for both ends of the cuts at 100,000, 200,000, and 300,000 ft of traverse, with 740, 1140, and 1470 ft of mixtures on the basis of 99 per cent pure to 99 per cent pure products. These are typical and are reproduced primarily to show the nice agreement of data and its reproducibility over very narrow spreads of gravity.

Run No. 67 is shown in part on Fig. 9. The data show this to have been a run on regular gasoline against No. 3 fuel oil at velocity of 2.03 ft per sec and a line temperature of 84.9 F. The gasoline had a specific gravity of 0.7394 and at the line velocity a Reynolds Number of 50,300; the fuel oil, 0.8510 specific gravity and Reynolds Number of 10,820. The Reynolds Number of the 50/50 mix calculated at 26,420. Gravitometer charts are reproduced for 50,000, 100,000, 150,000, and 200,000 ft of total runs. The length of mixture shown at these four distances calculated on 99 per cent pure to 99 per cent pure product was 590 ft, 890 ft, 1140 ft, and 1340 ft. The typical sine curve form of the gravitometer chart line will be readily recognized on these charts, and as this constitutes a valuable tool in the hands of a dispatching organization, more will be said about it later. It will be seen that these data were readily interpretable and that if enough runs were made it became a simple matter to predict and prove generic data on other combinations of products than those runs.

Fig. 10 shows experimental run No. 75 between gasoline of 0.7318 specific gravity and kerosine of 0.7994 specific gravity run at 0.96 ft per sec velocity with consequent Reynolds Numbers of 22,860 and 8,050 and on the 50/50 mix a Reynolds Number of 14,160. As we would expect, this run shows greater

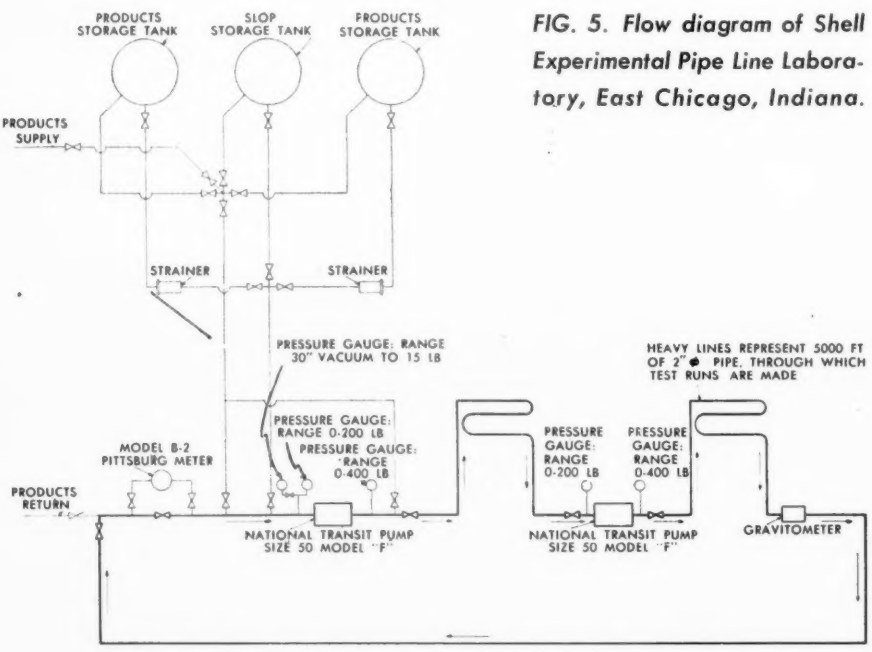

PRODUCTS STORAGE TANK
SLOP STORAGE TANK
PRODUCTS STORAGE TANK
PRODUCTS SUPPLY
STRAINER
STRAINER
PRESSURE GAUGE: RANGE 30" VACUUM TO 15 LB
HEAVY LINES REPRESENT 5000 FT OF 2" ø PIPE, THROUGH WHICH TEST RUNS ARE MADE
PRESSURE GAUGE: RANGE 0-200 LB
PRESSURE GAUGE: RANGE 0-400 LB
MODEL B-2 PITTSBURG METER
PRODUCTS RETURN
NATIONAL TRANSIT PUMP SIZE 50 MODEL "F"
PRESSURE GAUGE: RANGE 0-200 LB
PRESSURE GAUGE: RANGE 0-400 LB
NATIONAL TRANSIT PUMP SIZE 50 MODEL "F"
GRAVITOMETER

FIG. 5. Flow diagram of Shell Experimental Pipe Line Laboratory, East Chicago, Indiana.

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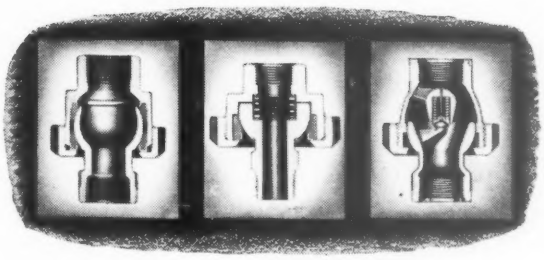

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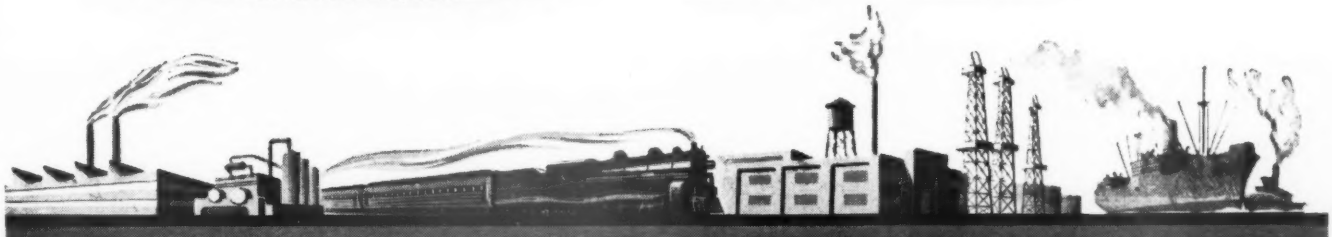

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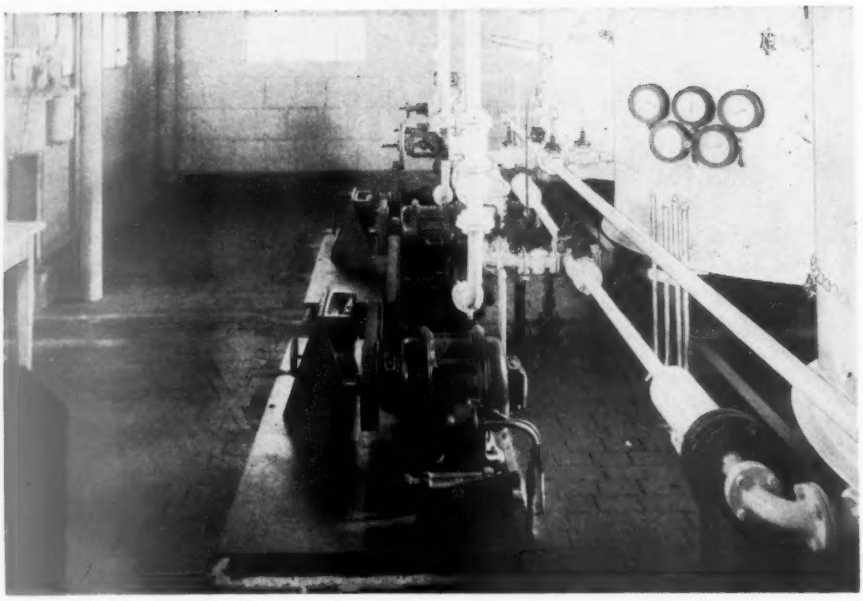


FIG. 6. Close-up of line pumps, variable speed drives, manifolding and product tankage.

mixing, and the curve of gravity at 50,000 ft has lengthened out to 630, 980 at 100,000 ft, and 1265 at 150,000 ft, roughly the same as shown before on 300,000 ft of run at 5.03 ft per sec velocity. Please note however that the form of the composition curve remains exactly the same differing only in length characteristics, and that all of this is pertinent to what follows.

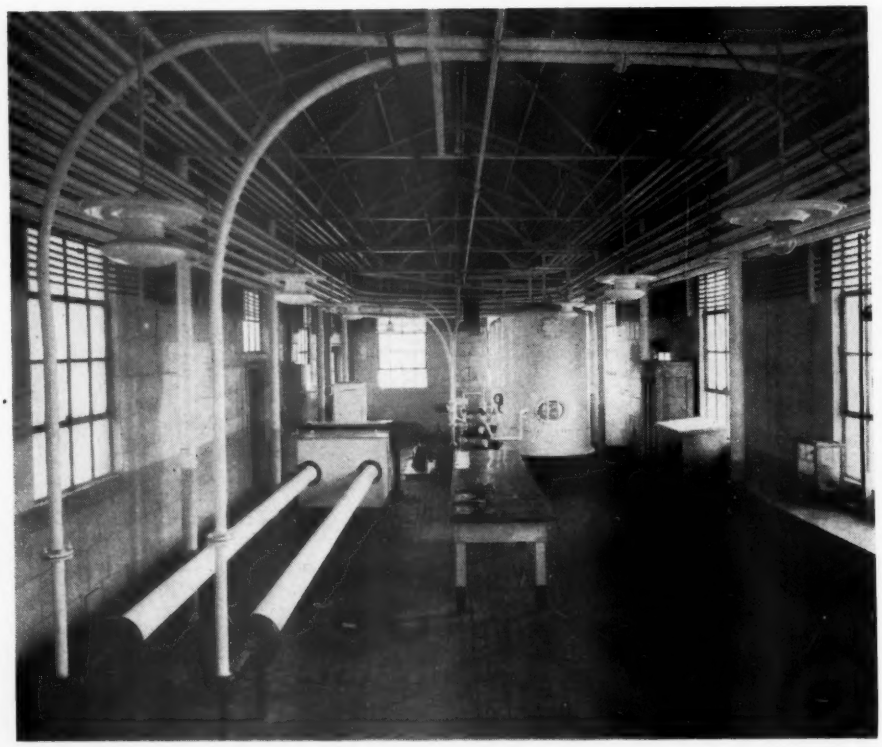
Previous investigators of pipe line mixtures had made various assumptions covering the control point in Reynolds Numbers below which it was unsafe to go in products pipe line work. Stanton and Pannell's data, later confirmed and supplemented by Heltzel and others, had given more or less accurate yard-sticks of the break point between viscous or laminar and turbulent flow in pipe, but the earliest work was done in smooth brass tubes of short lengths, and the confirmatory work was done in field lines by analysis of data that might in some cases have been suspect as far as the accuracy of pressure gauges and other factors of measurement were concerned.

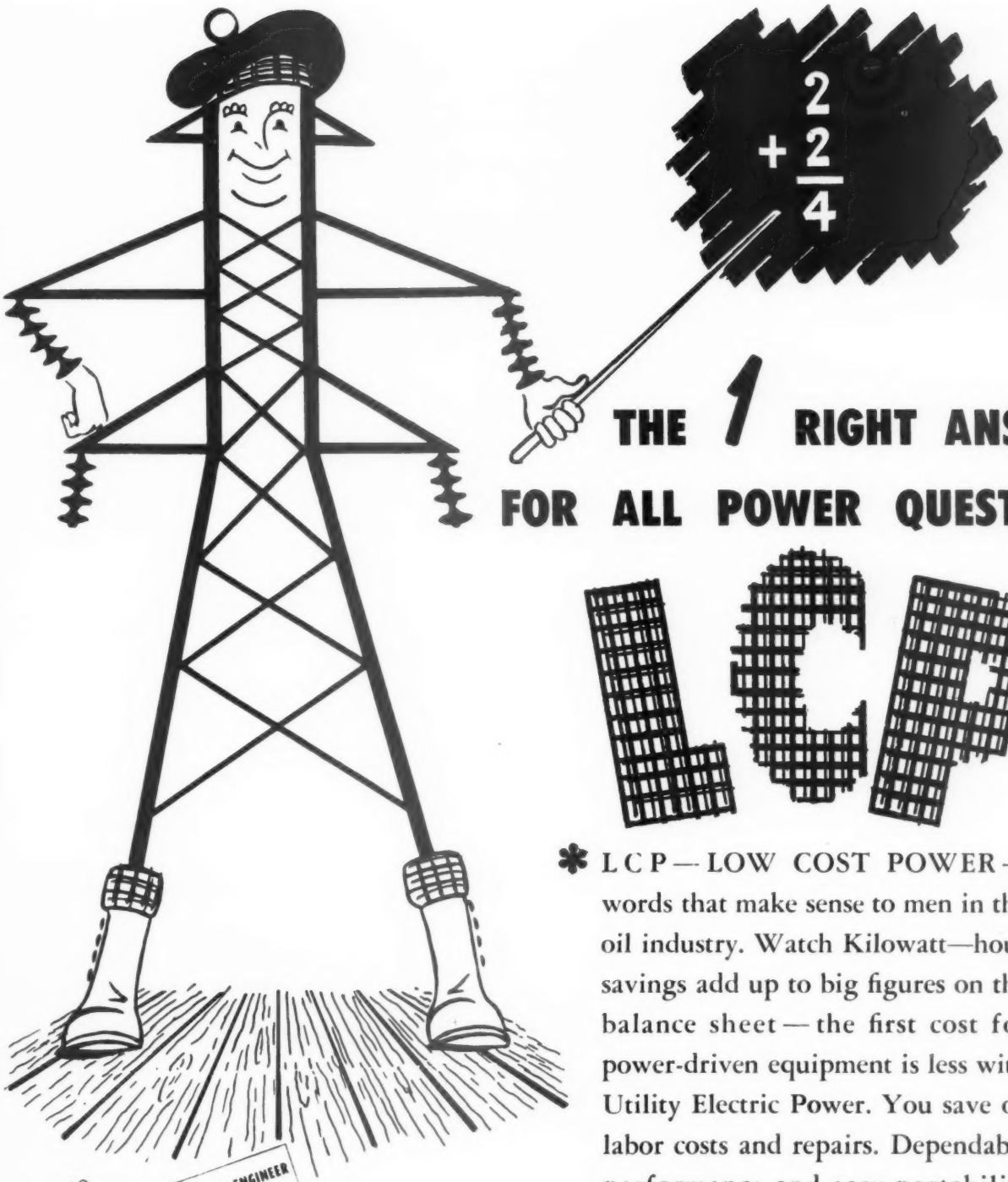
Work was done in other companies that was not released in the literature or was inconclusive from a quantitative standpoint, but the first real effort to design a formulary for mixtures in pipe lines of which we have any literature was the work of Brown and Fowler at the University of Michigan. Their data were derived from glass tubes $\frac{1}{8}$ in and $\frac{3}{8}$ in diam of 5 to 105 ft in length and used water against heavy salt solution as the miscible fluids, operating at Reynolds Numbers under 20,000. Their sampling methods were by semi-automatic collection of full line stream in successive containers, which meant that each sample was an average receipt from the line over a finite time. Their data, therefore, although accurate, was not conducive to determining exact relationships between product mixture and time, nor was it possible for them to predict commercial operation with exactitude because none of their tests were made at Reynolds Numbers equal to those usual to commercial operations. From their data Brown and Fowler concluded that an arithmetical average of Reynolds Numbers of the two products determined relative mixing rates, and after concluding laboratory work they correlated their lab findings with commercial operations on the Shell East Products Pipe Line of 8 in. diam and 350 miles length. The rather indifferent agreement between their lab data and commercial line operation they attributed to relatively poor control of line rates and sampling in the field. Although the latter is correct, the larger cause of divergence was more likely due to the fact that their experimental work was conducted at too low rates to represent actual operating conditions.

There has been much discussion among products pipe liners concerning the difference in mixing rates between a light product preceding a heavy product and a heavy product preceding a light product in a pipe line. General opinion seems to be that greater mixing takes place when the heavier product with lower Reynolds Number follows the light product in the line. Fig. 11 shows sections of the chart from our same run No. 67-No. 3 fuel oil against ordinary house-brand gasoline. A glance at the gravitometer charts shows the same characteristic mixing curves on both ends of the No. 3. The shapes of the curves are slightly different but their length is the same, and there is no real difference in the amounts of mixing. From this and many other similar runs we conclude that there is no significant difference between the two types of operation, nor have we been able to find any concrete evidence of such differences in our field operation.

We have said that all mixing curves show the same characteristic sine wave curve. You will note that this is only partly true. The front end of the break between products is steeper than the following end, and as the run progresses to greater distances the extended tail of

FIG. 7. Interior of experimental pipe line laboratory showing 2-in. piping around walls of building, gravitometer in left foreground, product tankage and line pumps in center background.





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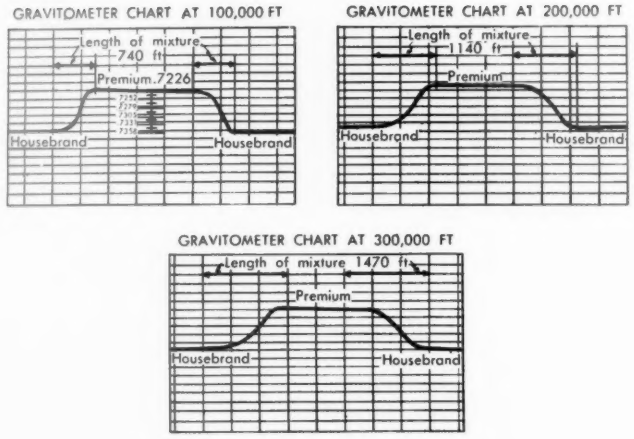


FIG. 8. Experimental pipe line.

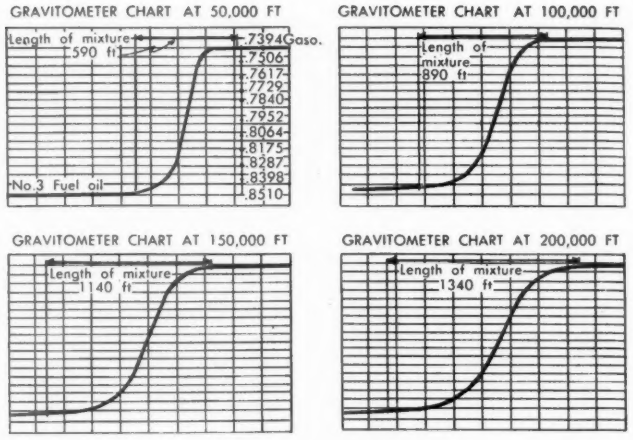


FIG. 9. Experimental pipe line.

MIXTURE RUN NUMBER 80 — HOUSEBRAND AND PREMIUM GASOLINE
AVERAGE VELOCITY = 5.03 FT PER SEC.
LINE TEMPERATURE = 83.4F

	SPECIFIC GRAVITY	REYNOLDS NUMBER
HOUSEHOLD GASOLINE	.7358	111,000
PREMIUM GASOLINE	.7226	123,900

REYNOLDS NUMBER 50/50 MIXTURE BLEND = 121,000

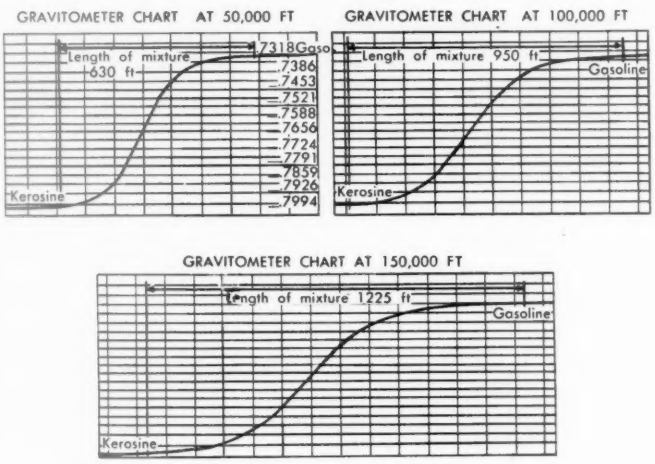


FIG. 10. Experimental pipe line.

MIXTURE RUN NUMBER 75 — GASOLINE AND KEROSINE
AVERAGE VELOCITY = 0.96 FT PER SEC.
LINE TEMPERATURE = 87.1F

	SPECIFIC GRAVITY	REYNOLDS NUMBER
GASOLINE	.7318	22,860
KEROSINE	.7994	8,050

REYNOLDS NUMBER 50/50 MIXTURE BLEND = 14,160

MIXTURE RUN NO. 67 — GASOLINE AND NO. 3 FUEL OIL
AVERAGE VELOCITY = 2.03 FT PER SEC.
AVERAGE TEMPERATURE = 84.9

PRODUCT	SPECIFIC GRAVITY	REYNOLDS NUMBER
GASOLINE	.7394	50,300
NO. 3 FUEL OIL	.8510	10,820

REYNOLDS NUMBER 50/50 MIXTURE BLEND = 26,420

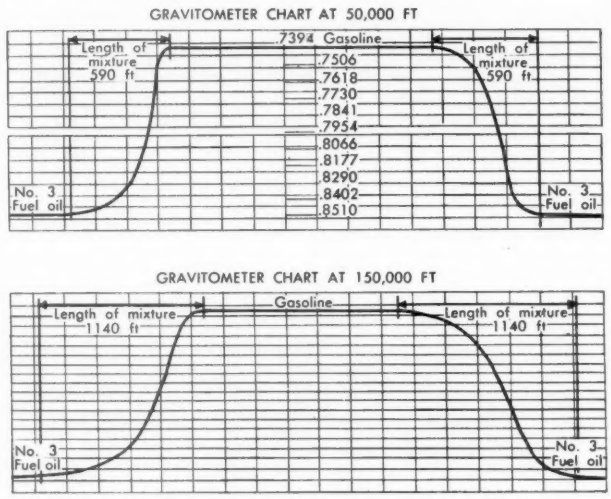


FIG. 11. Experimental pipe line.

MIXTURE RUN NUMBER 67 — GASOLINE AND NO. 3 FUEL OIL
AVERAGE VELOCITY = 2.03 FT PER SEC.
LINE TEMPERATURE = 84.9F

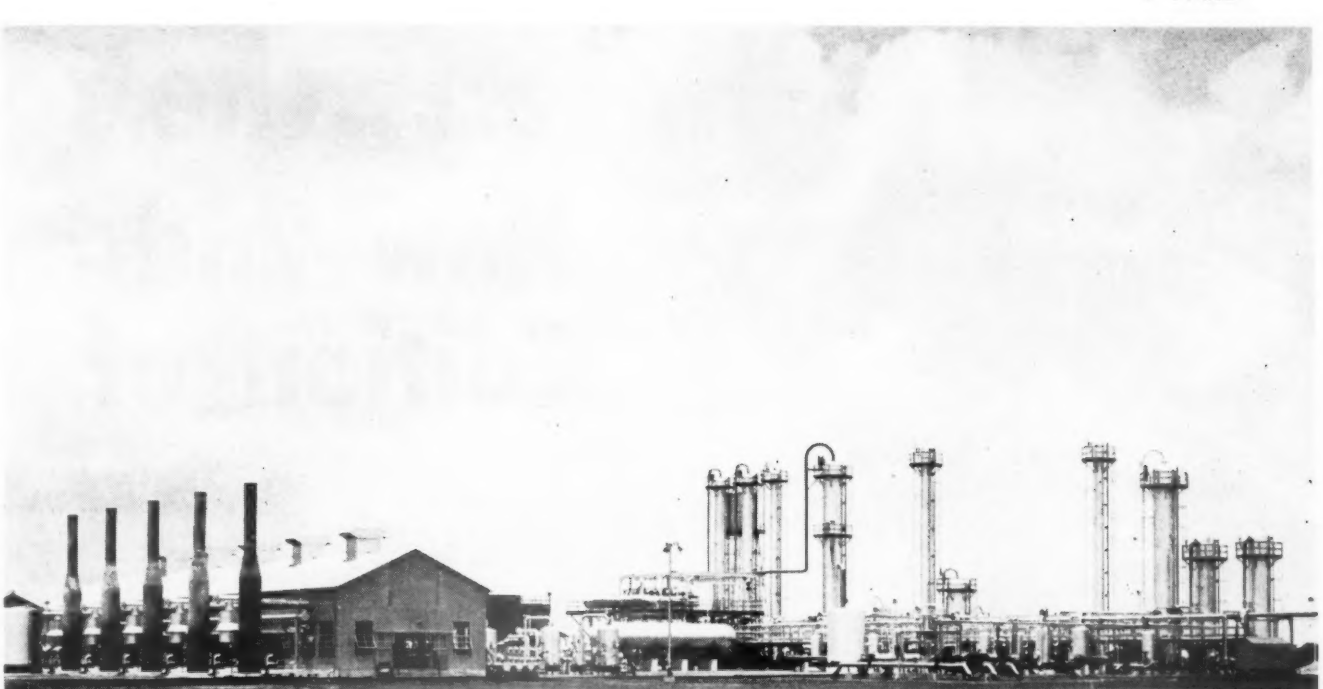
	SPECIFIC GRAVITY	REYNOLDS NUMBER
GASOLINE	.7394	50,300
NO. 3 FUEL OIL	.8510	10,820

REYNOLDS NUMBER 50/50 MIXTURE BLEND = 26,420

the sine curve becomes more evident. It would seem there were in reality two mechanisms at work governing the mixing rates, and we concluded that these could be explained as follows. The major mixing is a velocity diffusion of the two products into each other. Without going into all the data, we were able to prove to our own satisfaction that the 50/50 mix point was at the same location in the stream as the starting interface, and the diffusion mixing therefore must have spread both ways from interface in equal degree. The long tail on the sine curve was a secondary effect caused by the result of the first adhesion of liquid from the leading batch to the wall of the pipe, subsequently taken into the following liquid by dilution. From some rather involved mathematics we concluded that the thickness of this film of material was about 0.003 in., apparently remaining about the same regardless of velocity of the stream. This characteristic tail on the mixture curve is probably responsible for the misconception regarding different mixing rates dependent on whether heavy product precedes or follows. This phenomenon, however, is troublesome in commercial operations only because when burning oils are run against gasoline this long tail of mixture complicates the protection of flash point of the burning oil. It should be noted that the percentage mixture in this tail is very small, and usually cuts can safely be made while disregarding the minute effect of this small percentage mixing into the whole batch of burning oil. Flash points will be lowered by only 1 to 3 deg. which is usually within permissible limits.

These last items were digressions from our story but were sandwiched in to clear up misconceptions that have existed. To stay with the main theme we must concern ourselves with quantitative data on mixing at the interface. As was explained, the series of runs was designed to show lower and upper critical velocities at Reynolds Numbers in and around the laminar-turbulent range, and also to show the relative amounts of mixing well up in the turbulent range where most commercial lines were operated. We accumulated a tremendous mass of information covering the 250 runs, but that detailed information is of no interest here. It is better to set out the conclusions reached and the routes followed in reaching these conclusions. The basic data is on file, and if sufficient interest is shown it can be made available at a later date.

This paper is in two parts. Part 2 will follow in an early issue. * * *



Tomoconnor gasoline plant.

New Unit in Gas Conservation Program

By FRANK H. LOVE, *Managing Editor*

THE new absorption - type gasoline plant owned jointly by the Humble Oil and Refining Company and Quintana Petroleum Corporation in the Tomoconnor field, Texas, is the latest completed unit in Humble's long-range gas conservation program. This plant provides a means for taking casinghead gas from 593 oil wells, recovering the hydrocarbons, and putting the residue gas into commercial channels. Design capacity is for 35,000,000 cu ft of gas a day. At the present time, however, about 22,000,000 cu ft is being processed, manufacturing approximately 13,000 gal of natural gasoline, 16,000 gal of propane, and 16,000 gal of LPG. Recovery of hydrocarbons is approximately 2 gal per M cu ft of gas. An analysis of the inlet gas is given in Table 1. It will be noted that the gas is unusual in that the iso fractions are in greater volume than the normal fractions.

The Tomoconnor plant is receiving gas through two lines after it has been separated from the oil at the wells. A

EXCLUSIVE

16-in. line brings gas to the plant from the south and a 20-in. line serves wells to the east.

Suction pressure averages 58 psi and the gas is compressed in two stages to a discharge pressure of 800 psi. The gas is discharged at this pressure to the main absorber where the hydrocarbons are picked up by the absorption oil, the residue gas passing through a scrubber and a dehydration unit before being metered into the pipe line of the gas transmission company to which it is sold.

The main absorber is a 5-ft 6-in. diam by 49-ft vessel that operates at a pressure of 800 psi. Absorption oil circulation is at the rate of 318 gpm. Rich oil from the main absorber passes into a 300-psi flash drum, vapors from this drum going to the high pressure reabsorber, which is 2 ft 6 in. in diam and 58 ft high and operates at a pressure of 280 psi. Oil circulation is at the rate of 60 gpm. Vent gas from the reabsorber goes into the plant fuel system. Rich oil from the reabsorber combines with the stream from the flash tank, the commingled streams passing through four oil heat exchangers and pre-heaters before entering the primary stripper. The 5-ft diam by 22-ft high stripper is operated at a pressure of 190 psi. A temperature of 415 F is maintained on this column and the overhead vapors pass through condensers into a stripper receiver, the function of the latter being to remove entrained water. A 190-psi back pressure is held on this stripper receiver. Condensate and non-condensed gases are fed into a 3-ft diam by 62-ft low pressure reabsorber through which oil is circulated at the rate of 55 gpm.

Residue gas from the low pressure reabsorber is scrubbed and sent to the plant fuel system.

Rich oil from the low pressure reabsorber, together with condensate

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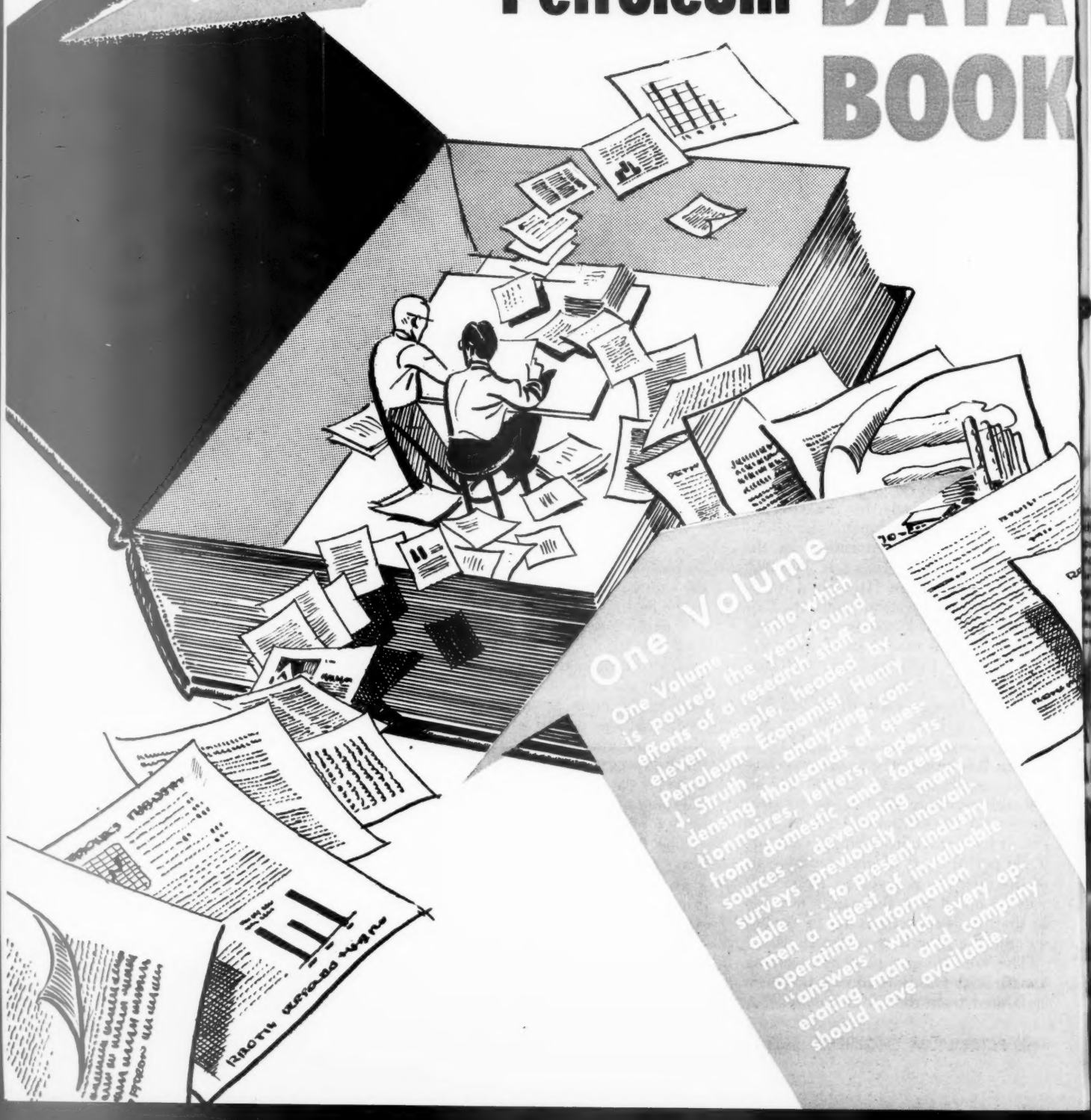

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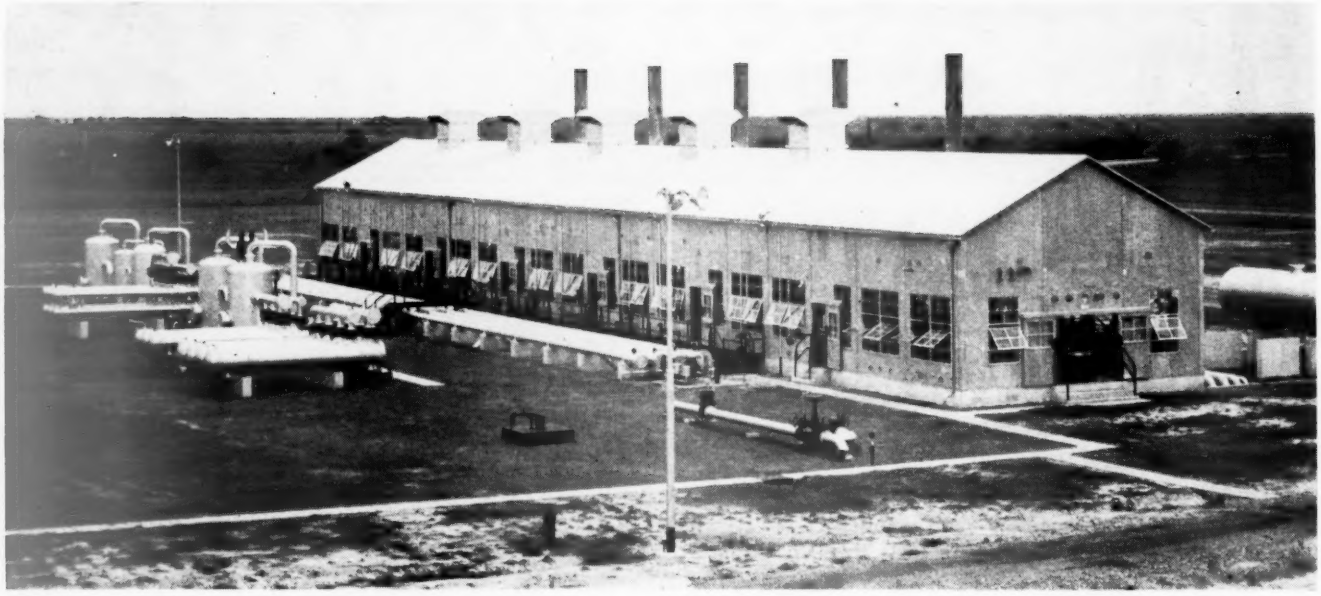


View taken from top of cooling tower showing exterior of compressor station building, suction and discharge headers, jacket water coolers, and interstage scrubbers.

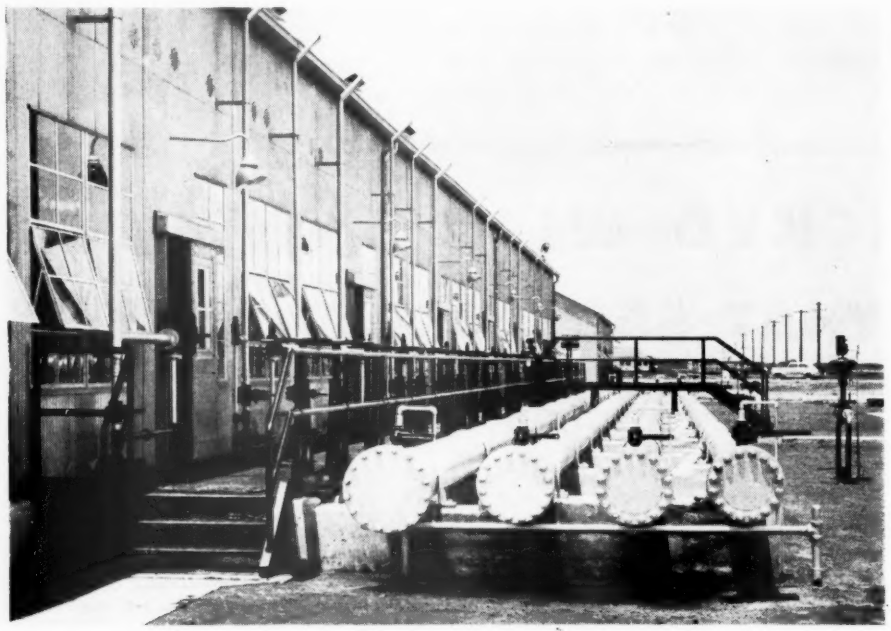
from the primary stripper, is discharged through heat exchangers and preheaters to join the stream from the bottom of the primary stripper, these combined streams entering the main still. The latter, sometimes called the evaporator dephlegmator, is 5 ft 6 in. in diam and 60 ft high. The base temperature is 450 F and the operating pressure 90 psi.

Denuded oil from the base of the main still passes through oil heat exchangers countercurrent to the rich oil. Overhead vapors from the still pass through primary condensers into the reflux receiver. Non-condensed vapors go through two final condensers and into the still receiver. Non-condensed gases from the still receiver are recompressed to 300 psi then cooled, the condensate dropping out into the raw make tank. This condensate is joined in the raw make tank by liquid from the still receiver, which vessel is 8 ft in diam and 40 ft high, being operated at a pressure of 300 psi.

Non-condensed gases from the raw make tank pass into the high pressure reabsorber.

In the event that the recompressor cylinders are unable to handle the full volume of gases from the still receiver, such gases can be fed into the low stage suction and recycled through the plant.

Liquid from the raw make tank is pumped to the deethanizer. This column is 2 ft 6 in. in diam and 60 ft high and is operated at a pressure of 520 psi. Here the methane and ethane are removed in order to produce commercial propane in the depropanizer. Vent gases from the top of the deethanizer are also fed into the high



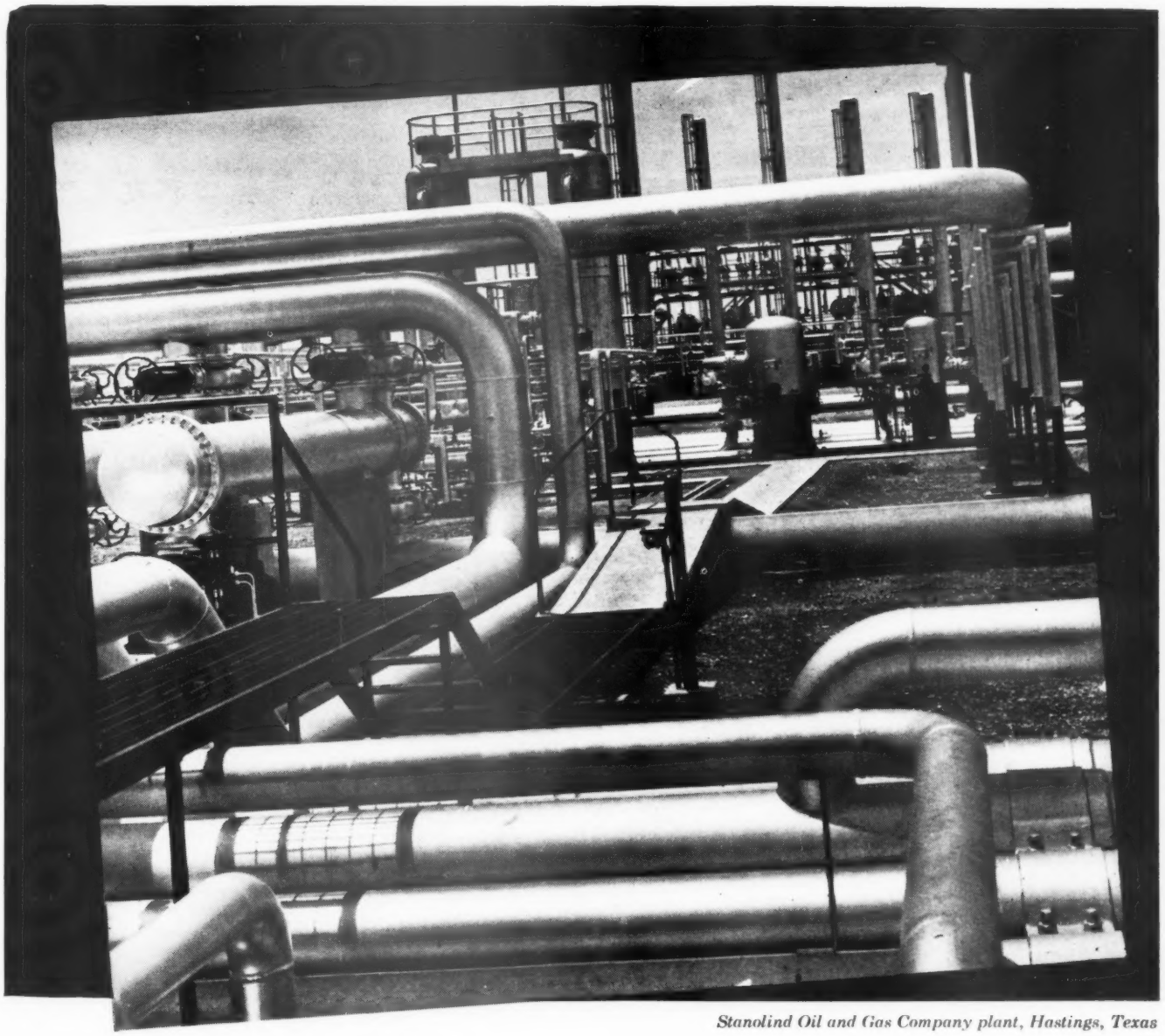
Compressor suction and discharge headers. From left to right are low stage suction header, low stage discharge header, high stage suction header, and high stage discharge header.

pressure reabsorber. Bottoms from the column constitute feed for the depropanizer.

The depropanizer is operated at a pressure of 240 psi and is a column 3 ft 6 in. in diam by 60 ft high. The overhead product of the depropanizer consists of commercial propane. Bottoms constitute feed for the debutanizer, a 3-ft 6-in. by 60-ft tower that operates at a pressure of 135 psi. The overhead from the debutanizer is blended with propane to give as 80-lb vapor pressure LPG product. This product goes to three storage tanks, from which it is pumped either to the truck loading rack or the trankcar loading rack.

Excess propane not used for blending with the debutanizer overhead passes to three propane storage tanks from which it also can be pumped to either of the loading racks.

Bottoms from the debutanizer consist of 18-lb RVP natural gasoline. This passes through two heat exchangers, heating deethanizer feed in the process, goes through a final



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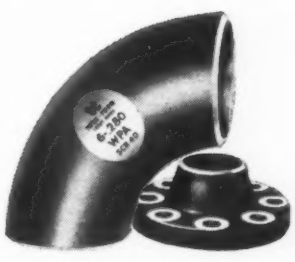


cooler, and enters four gasoline storage tanks. From storage it is pumped to the tankcar loading rack.

In addition to the 593 oil wells, the plant is also connected to five gas wells, so that in event of plant failure or shut down Humble can fulfill its gas sales contract. Should such an eventuality occur gas from these wells, upon entering the plant, would pass through three heaters, a scrubber, and a dehydrator before going to the sales gas meter run.

▸ **Compressor plant.** The compressor plant consists of five 1000-hp gas-engine-driven compressors. Each unit has two high stage and two low stage cylinders. The low stage cylinders have a 13-in. bore and 14-in. stroke, and the high stage cylinders 8½-in. bore and 14-in. stroke. Two of the compressors have recompressor cylinders, one on each unit. These cylinders have a bore of 7⅛-in. and a stroke of 14 in. Engine jacket water is treated with a corrosion inhibitor. The engines are provided with automatic devices to shut down the units in event of low lubricating oil pressure or water failure.

▸ **Steam plant.** Steam requirements for processing and power are supplied by four 150-hp oil country boilers that supply 25,000 lb per hr of saturated steam at 300 psi.

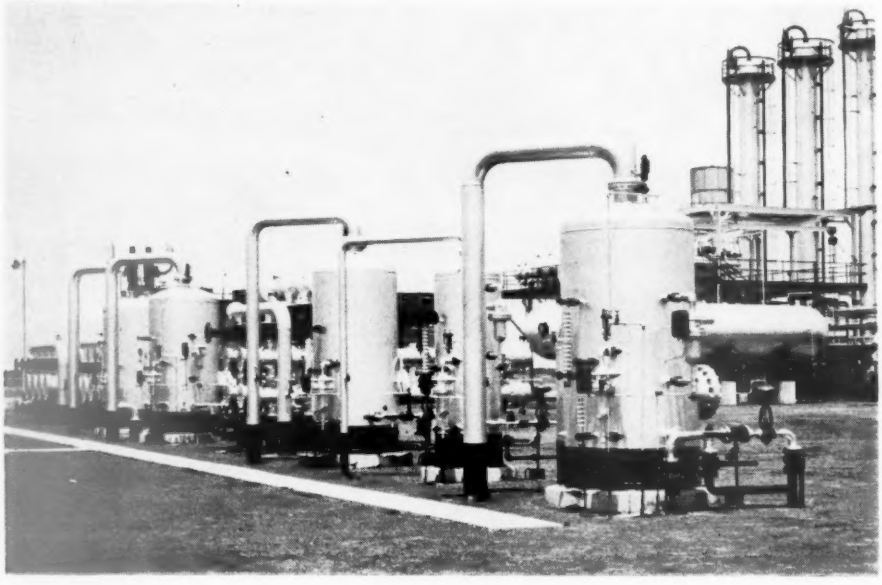
▸ **Generator plant.** Electricity for plant and camp use is provided by three 250-kw generators driven by 370-hp, 8-cylinder, angle-type gas engines. The electrical load requires only two generator sets, thus giving 50 per cent standby capacity. The engines are equipped with low oil pressure and high water temperature shutdowns.

TABLE 1. Analysis of inlet gas.

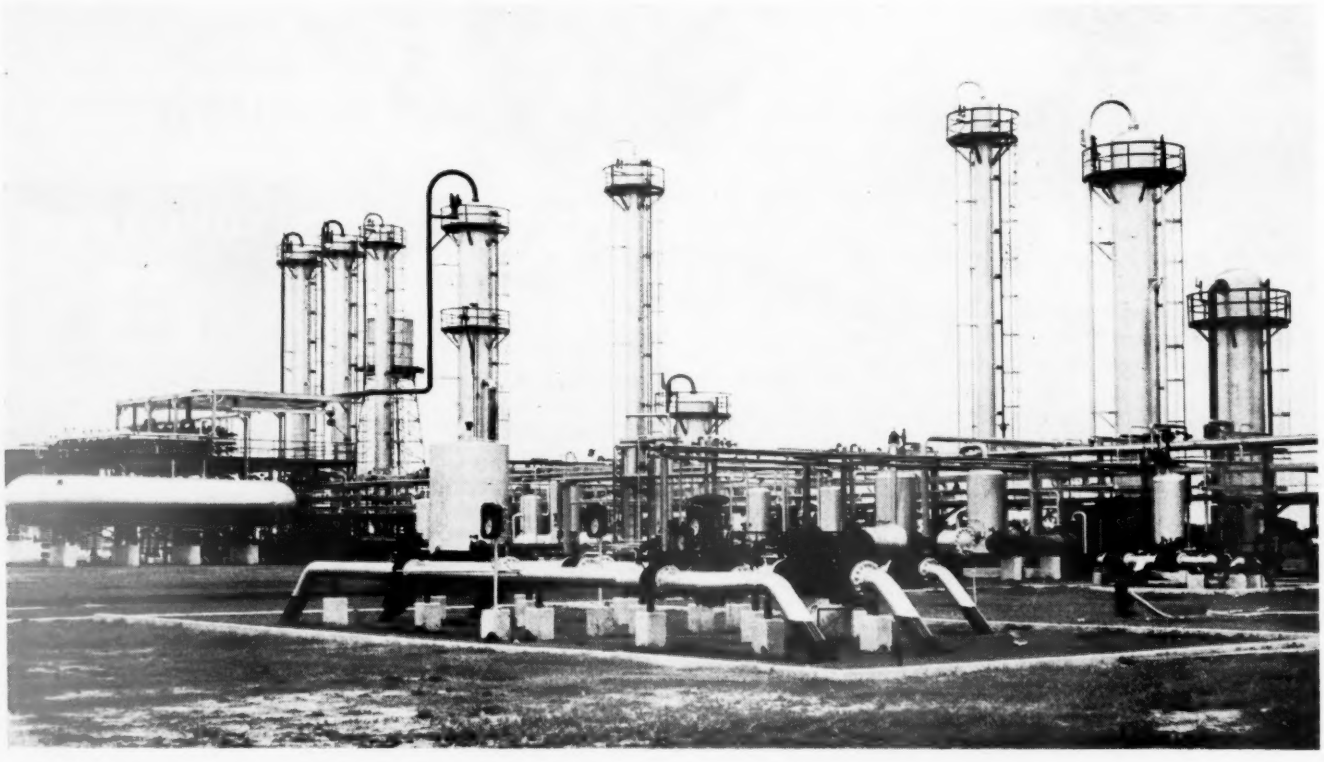
Component	*Mol. %*
Methane	85.52
Ethane	7.29
Propane	4.06
Isobutane	1.00
N-butane	0.99
Isopentane	0.32
N-pentane	0.27
Hexane	0.27
Heptane plus	0.28

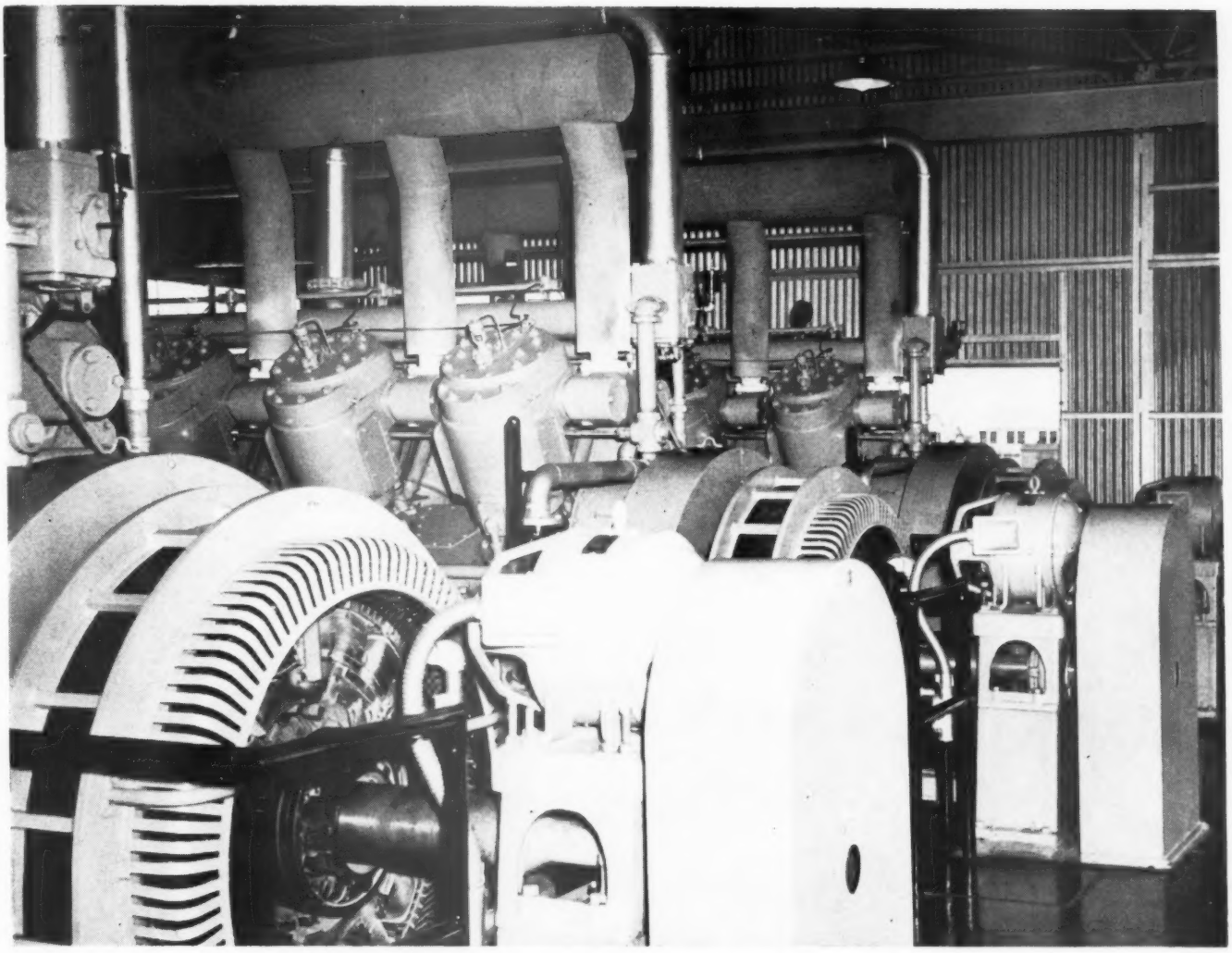
▸ **Water system.** Two water wells have been drilled on the plant site to provide makeup for boiler feed and cooling tower. Makeup for the engine jacket water system is steam condensate. All water is treated, boiler feedwater with phosphate to prevent scale deposition, cooling tower water with phosphate and chlorine to keep down algae, and engine jacket water with dichromates to inhibit corrosion.

The cooling tower is a 4-cell unit of the induced draft type. Water is circulated at the rate of 8000 gpm by single stage deepwell type pumps.

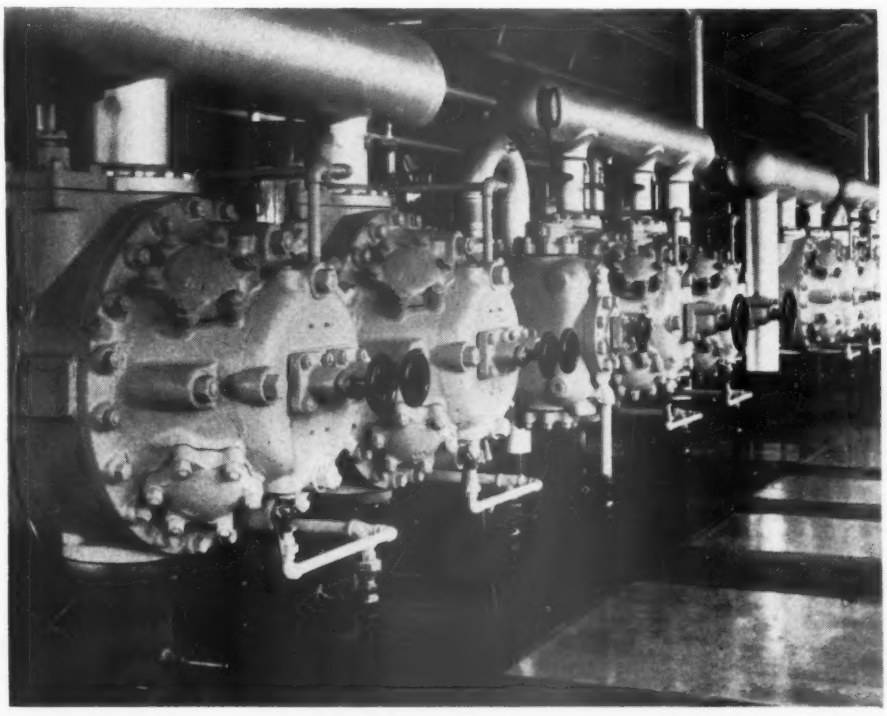


Left—Scrubbers and gas and jacket water coolers. Below—Processing towers and absorbers. Meter run in foreground.





Electricity is provided by three 250-kw generators driven by 370-hp, 8-cylinder, angle-type gas engines (above). The compressor plant (below) consists of five 1000-hp gas-engine-driven compressors. Gas is received at a pressure of 58 psi and discharged at 800 psi.

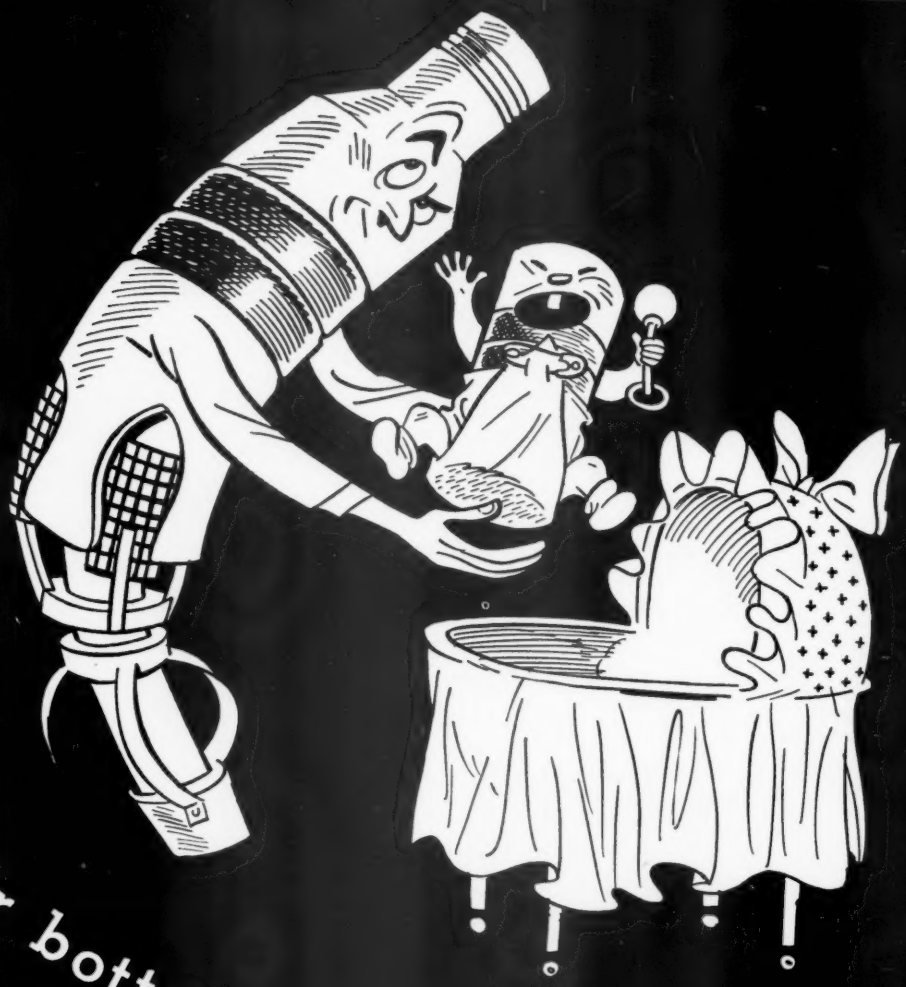


There are three of these pumps, one serving as a standby. The purge rate is 50 gpm.

▸ **Protective system.** The plant is protected by a complete emergency shutdown system. The boilers can be shut down from four remote stations in case of emergency and the compressors from five locations. Further, the entire plant can be shutdown by the manipulation of but two valves. In addition, the inlet gas scrubber and the fuel gas scrubber are equipped with high liquid level alarms and high level shutdown.

▸ **Storage tanks.** The four gasoline storge tanks measure 12 ft diam by 50 ft and have a capacity of 1000 bbl each. Propane tanks are three in number, measure 8 ft 10 in by 62 ft. and have a capacity of 700 bbl each. There are three tanks for the storage of LPG. These also have a capacity of 700 bbl each, but measure 10 ft by 40 ft.

▸ **Contractor.** The Gasoline Plant Construction Corporation of Houston, Texas, was the contractor in charge of building the plant. ★ ★ ★



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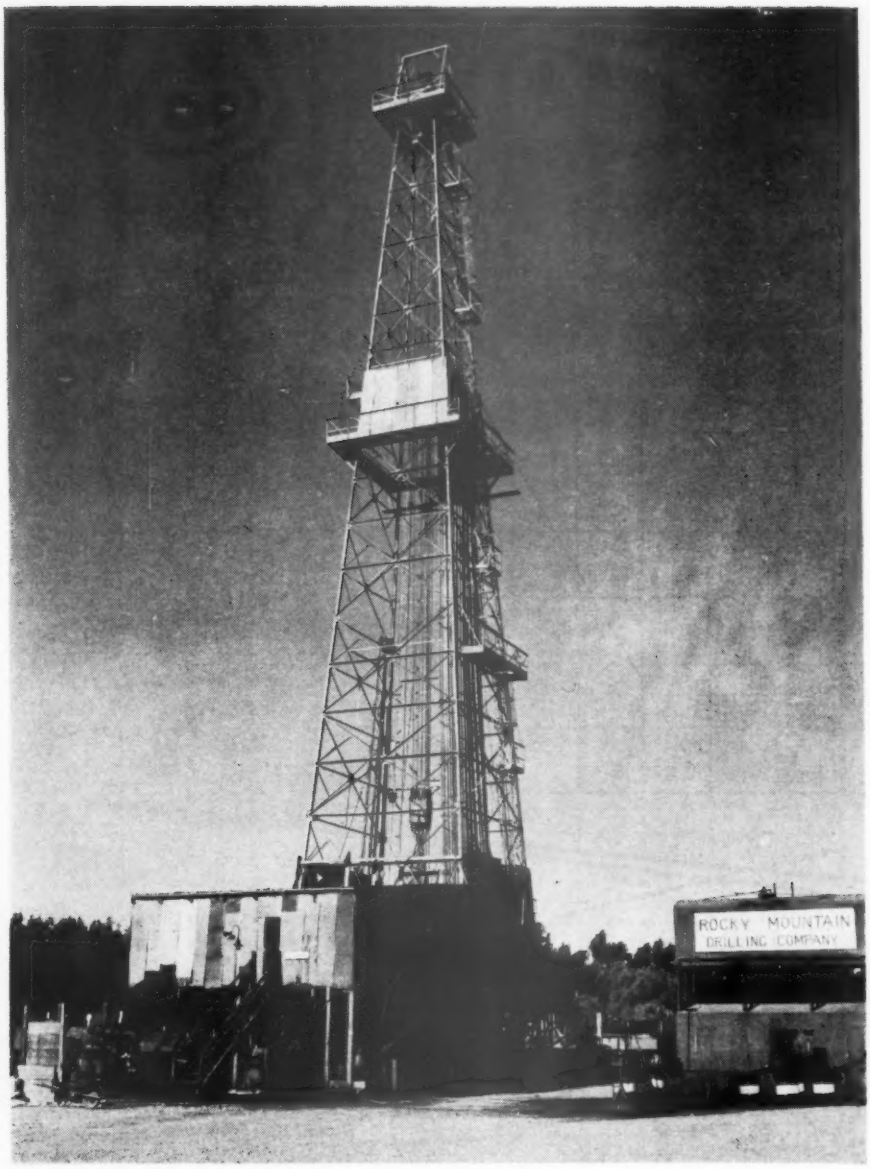

Standard Oil Company's Maxwell No. 1, near Ventura, California, drilled to a depth of 17,696 feet by Rocky Mountain Drilling Company, using a diesel powered rig. This is the deepest well ever drilled with diesel power.

Deep Well Breaks Four Drilling Records

By NICHOLAS A. D'ARCY, JR.

THE Rocky Mountain Drilling Company, drilling for the Standard Oil Company of California, broke three world's records and one California record in drilling Maxwell No. 1 near Ventura, California. This well, drilled to a total depth of 17,696 ft, was drilled in the fastest time to a comparable depth, is the deepest well ever drilled by a drilling contractor, is the deepest well ever drilled with power equipment, and is the deepest well ever drilled in California.

The well was remarkably free from trouble until the pipe stuck at the final depth, but the most surprising feature of the entire performance was the splendid results obtained with the heavy duty power drilling equipment. The drawworks powered by four 6-cylinder diesel engines hoisted the long strings of drill pipe in about the same time required by conventional steam rigs in the same field. The slush pumps were overloaded to more than double their rated horsepower capacity, but they performed to the entire satisfaction of the contractor.

▸ **Hoisting equipment.** The entire rig was purchased in 1947 and it was described as a modern power rig capable of drilling 12,500-ft wells. It has lived up to and far exceeded its rated capacity. Maxwell No. 1 was the second well this rig drilled. The drawworks itself is modern in every respect and similar to many power rigs designed for drilling to 12,000 or 13,000 ft, but it was never intended as a depth-breaking piece of equipment. Precision cut teeth sprockets, oil tight chain guards, friction drum clutches, and dual 40-in. hydromatic brakes with master cathead and spinning catheads are similar to the specifications on countless other similar rigs. It was careful supervision and maintenance that made this a record-breaking rig.

Adequate hoisting horsepower was provided by the four diesel engines each capable of developing 300 hp. The 1200 available hoisting hp allowed the drilling crew to consistently hoist from below 17,000 ft in 5 hr and to run in the same length of pipe in 4½ hr. This hoisting performance was made with approximately 6000 ft of open hole below 12,000 ft where care in hoisting necessitated slower than maximum hoisting speed. Air clutches in the rig drive group gave the drilling crew complete flexibility of operation. The clutches were used to drive the two slush pumps, also for the rig master clutch and to connect the four diesel engines to the rig drive group.

▸ **Slush pumps.** Two power pumps rated at 350 hp each were driven from the rear of the power compounding rig drive. These 16-in. stroke pumps began with 6¾-in. pistons and they were used to a depth of 11,293 ft after reaching circulating pressures of 1250 psi. Six-in. pistons and liners were used between 11,293 and 11,919 ft at which depth 7-in. casing was set and the 4½-in. drill pipe was replaced with 3½-in. A change was made to 5½-in. pistons and liners before drilling was resumed with the smaller drill pipe and this size was used to the completion of the well. Special pump drive sheaves

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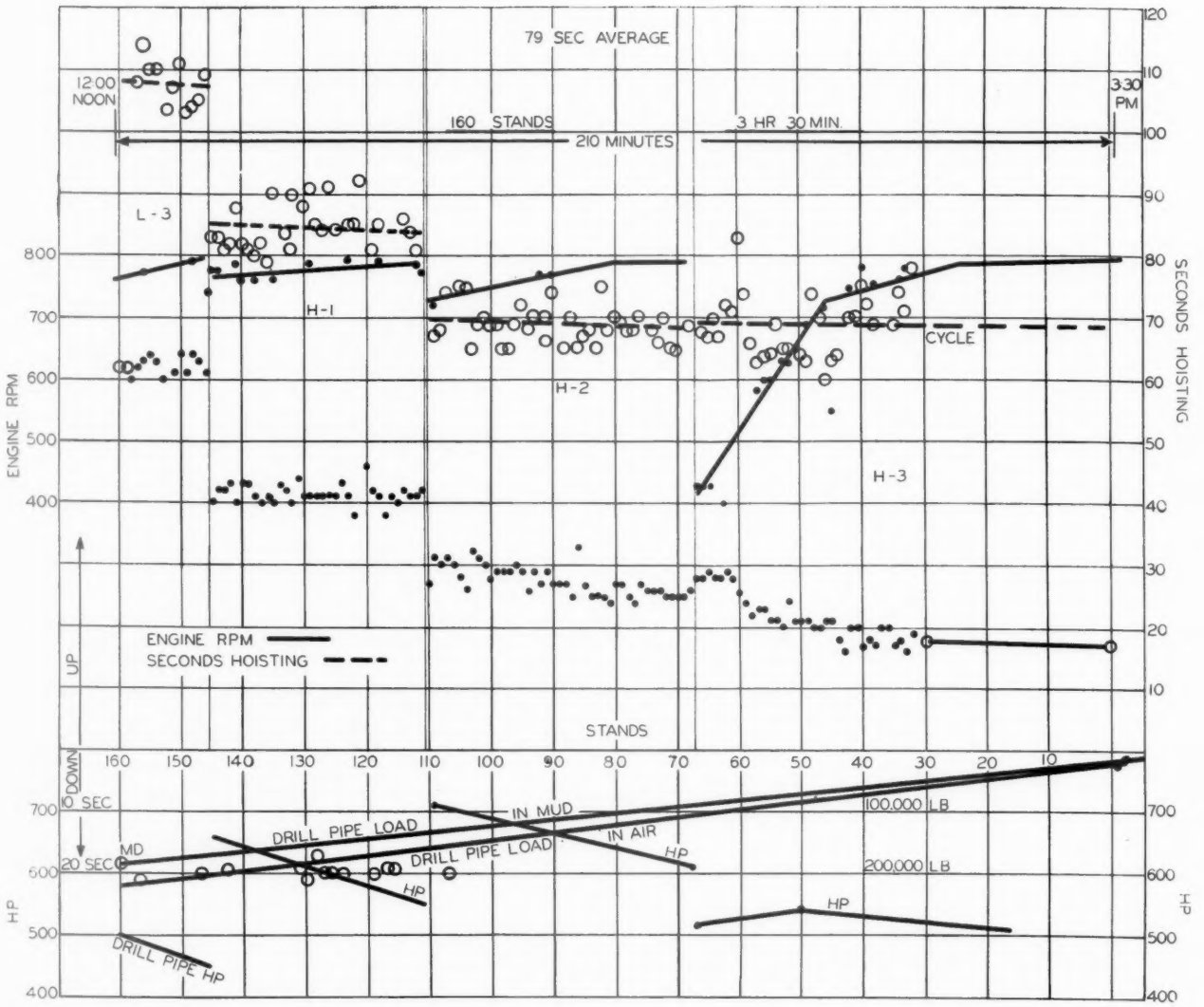

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160 STANDS	3½-IN	13.30 LB.	1280 LB.	204,000 LB
66-FT COLLARS		75 LB.		5,000 LB
		IN "AIR"		224,000
				15,000
				174,000
		IN "MUD"		189,000 LB

14,605 FT DEEP—88-FT STANDS—3½-IN. PIPE

Detailed record of hoisting time when 160 stands of drill pipe were being pulled.

were installed to allow slower than normal operation of the pumps in order to reduce circulating volumes and pressures at great depths. Circulating pressures from 1700 to 2500 psi at pump speeds of 22 spm were maintained while drilling below 17,000 ft. The two slush pumps operating in parallel circulated all the drilling fluid. Circulation at 22 strokes with 5½-in. liners provided a rising velocity of the mud of approximately 2½-lineal feet per second. This rate of circulation is lower than normally maintained under normal drilling conditions but an increase in circulation from 150 to 154 gpm raised the circulating pressure from approximately 1700 psi to more than 2600 psi. The fact that turbulence was reached in the drilling string dictated the maximum rate of flow of drilling fluid. A 7¼ by 18 pump powered by a separate 8-cylinder engine was installed after the 7-in. casing had been set. This pump was used to mix and move mud and to perform auxiliary duty as required.

▸ **Drilling string—wire line.** The only major change in the drilling equipment made while drilling the deep well was on Christmas day when a new 300-ton traveling block was installed. One 6-sheave crown block and a single swivel were used for drilling the entire well. Improved plow steel 1¼-in. wire rope with preformed centers in 3000-ft lengths was used for the casing line. An old line was used for drilling surface hole and it was replaced as soon as the 13⅜-in. casing was set. The next line was used to a depth of 11,919 ft and was replaced before setting the 7-in. casing. The second line drilled to a depth of 14,098 ft and the third line was installed at 16,621 ft and it completed the well.

Rocky Mountain Drilling Company has worked out a careful method of moving its drilling line in order to obtain the maximum ton-miles with safety. At depths below 12,000 ft the line was moved daily or after each round trip and was cut off according to Rocky Mountain Drilling Company's regular schedule. This practice insures uniform wear of the line and prevents too much build-up on the drum.

A combination drum-shaped wire line tie down and weight indicator situated under the derrick floor at ground level makes it easy to move the line in accordance with this program and it also provides an accurate source of weight indication.

Again WHITNEY Leads the Field

IN OIL FIELD CHAIN DESIGN

with

New "Snap Ring" Construction

- **eliminates Cotter Pins**
- **does not break or vibrate off**

Offset Links
make adjustments easy

Snap-Rings
hold tight on the pin

Ever since its inception in 1896, Whitney has pioneered in the development and improvement of all types of chains for all types of industry.

Today Whitney leads again with the *new Snap-Ring Construction* in oil field chains. This advanced Whitney design completely eliminates the use of cotter pins which often shake loose or break. The *Snap-Rings* are tight and stay tight on the pin . . . cannot vibrate or work off. They are easily installed . . . easily removed. No special tools required.

The combination of the *Offset Construction,* which makes on-the-job adjustments easy, *plus* the *Snap-Ring* design makes Whitney Oil Field Assembly Chains the outstanding choice for dependable, trouble-free operation in oil field service.

Get the full facts on this new chain design today.

It Pays to Specify Whitney Chain

WHITNEY CHAIN & MFG. CO.
Division of Whitney-Hanson Industries, Inc.
217 HAMILTON STREET, HARTFORD 2, CONN.
Oil Country Warehouses located in Dallas and Los Angeles

A rotary torque indicator was also used on this rig. It indicates the chain tension in the rotary table drive chain through a rubber roller and hydraulic pressure indicator. The torque indicator was useful in preventing twist-off with the small drill pipe at extreme depths.

▸ **Supervision.** The fact that Maxwell No. 1 was drilled to 17,696 ft with little trouble and in the fastest time ever made to that depth even when using standard power equipment is a tribute to the close supervision given this well. Roy E. Carpenter, Rocky Mountain Drilling Company tool pusher, was on the job from the day of spudding to the day the well was abandoned. This continuity of supervision on the part of the drilling contractor resulted in Carpenter having an intimate knowledge of the characteristics of the well at all times. George Collins, of the Standard Oil Company of California, was the resident drilling representative for the company and he was very helpful in his close cooperation with the drilling contractor. Below 11,919 ft it was deemed advisable to include starch in the mud and a careful check was kept of all mud problems while the deep drilling was in progress. A complete mud change was made using special clay, lime water, and starch after cementing 7-in. casing at 11,877 ft. In addition to the close personal supervision of the men who were on the job full time, both Standard Oil Company and the Rocky Mountain Drilling Company gave freely of their most experienced help to solve current problems as they arose.

It is a tribute to the close supervision of the resident men and to the overall help given by top management of the two major companies that this well was drilled to 17,696 ft without encountering a major problem. It is regretable that the drill pipe became stuck at that depth and that it could not be freed despite all efforts.

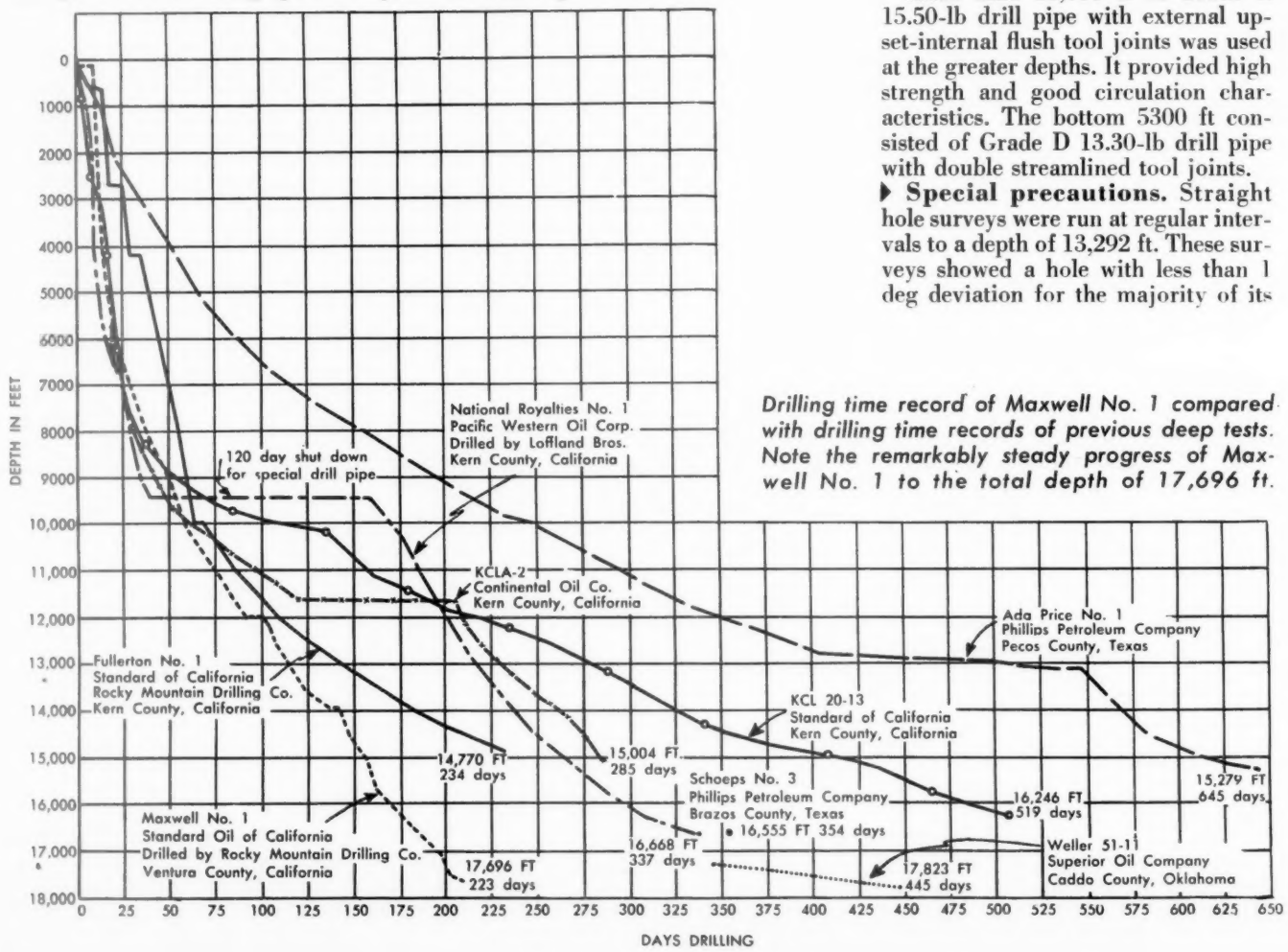
▸ **Mud control.** Drilling conditions above 11,919 ft made it possible to use clay base mud without adding weighting material. The main mud treatment above this point was treating all the water used to reduce its hardness. Below 9300 ft some trouble was encountered getting out of and particularly going back into the hole due to build-up of mud cake probably through loss of water to the sandy formations. It was often necessary to ream when going in with a new bit and the crews were required to pull up above 9000 ft every 8 hr to remove the build up of mud cake.

Seven-inch casing was set when the hole reached 11,919 ft and starch base mud replaced clay base mud when drilling operations were resumed. Keith Bright spent much time on mud control from that depth down but the drilling operations never required extreme mud treatment. The maximum weight of mud never exceeded 95 lb and no weighting material was added until the well was 16,520 ft deep. The starch base mud required close supervision, however, and much of the credit for the speed of drilling goes to the use of suitable mud. It is interesting to note that the crew drilled 80 ft on the last day of drilling operations and the average daily drilling was just under 80 ft for the entire well.

▸ **Drill pipe.** The largest possible hole was drilled below 11,919 ft. A 5⅞-in. bit was the largest that could be run in the 7-in. casing and this size hole was carried to the bottom. Drill pipe of 4½-in. diam was used above 11,919 ft but this was laid down after the casing was set and it was replaced with 3½-in. Some 13.30-lb drill pipe with 4⅝-in. OD external upset joints was used to a depth of almost 14,000 ft. It was laid down to eliminate possible fishing complication as one could not wash over it inside the 7-in. casing.

More than 11,700 ft of Grade E 15.50-lb drill pipe with external upset-internal flush tool joints was used at the greater depths. It provided high strength and good circulation characteristics. The bottom 5300 ft consisted of Grade D 13.30-lb drill pipe with double streamlined tool joints.

▸ **Special precautions.** Straight hole surveys were run at regular intervals to a depth of 13,292 ft. These surveys showed a hole with less than 1 deg deviation for the majority of its



Drilling time record of Maxwell No. 1 compared with drilling time records of previous deep tests. Note the remarkably steady progress of Maxwell No. 1 to the total depth of 17,696 ft.

Baash-Ross News

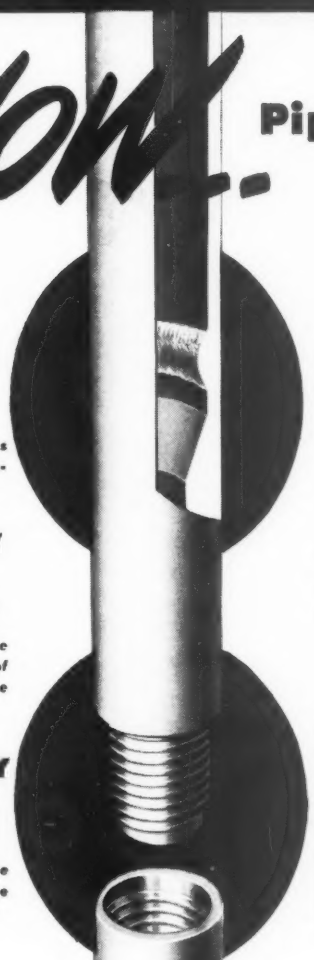
BAASH-ROSS TOOL COMPANY • LOS ANGELES • HOUSTON • OKLAHOMA CITY • NEW YORK

OUR 28th YEAR

NOW—

Pipe strings specially designed for today's deep-well cutting, clean out and other small-pipe operations . . .

Baash-Ross *High Strength* Small-Diameter PIPE STRINGS!



FLASH WELDED JOINTS

eliminate weaknesses of ordinary joint-to-pipe connections!

UNUSUALLY HIGH STRENGTH

as much as 3 times the tensile and torque of other strings with the same diameter!

EXTERNALLY FLUSH DIAMETER

insures free passage through other pipe without hanging up!

To match the deep well performance of Baash-Ross Cutting and Fishing Tools and Baash-Ross Power Swivels, Baash-Ross can now supply you with a new type of small-diameter pipe strings which feature unusually high strength factors — *both in tensile and torque!*

THE HIGH OVERALL STRENGTH IS ACHIEVED THROUGH THESE IMPORTANT FACTORS . . .

1 HIGH STRENGTH PIPE:
The pipe itself is made from chrome-molybdenum alloy steel tubing that is cold-drawn and normalized to provide very high strength-to-weight ratios in the pipe sections themselves.

2 HEAT-TREATED TOOL JOINTS:
The tool joints are also made from alloy steel that is specially heat-treated to combine wear-resisting hardness with shock-resisting toughness and strength. The tool joints are internally upset to provide ample metal for the threads, and the thread pattern has been carefully engineered to combine high strength with easy make-up.

3 FLASH WELDED CONSTRUCTION:
The final step to insure all-around high strength is the unique method by which the pipe is joined to the tool joints. A specially-developed flash-weld process is used that not only joins the tool joints *directly* to the pipe (eliminating any threads or other weak points between pipe and joints) *but provides a weld section that is actually stronger than the pipe itself!*

RESULT—a small diameter, light weight pipe string with unusually high strength properties . . . minimum tensile, 100,000 lbs./sq. in.— minimum torque, 47,500 lbs./sq. in!

Completely Flush Outside Diameter In addition to small diameter, low weight, and unusually high strength, Baash-Ross Small-Diameter Pipe Strings also feature a completely flush outside surface with no bulges or increased diameters to hang up or cause difficulties when working inside of other pipe strings. Note that there are no external beads or projections of any kind at the welded joint — and the tool joints are of the same outside diameter as the pipe — thus assuring an absolutely flush surface at all points.

Accessory Equipment To insure maximum adaptability and convenience in using Baash-Ross Small-Diameter Pipe Strings, the following accessory equipment is also available . . .

ELEVATOR PLUGS
These plugs are inserted into the top joint of the Small-Diameter Pipe String to provide a convenient elevator shoulder for supporting the string and handling the flush pipe sections. Made of heat-treated and hardened alloy steel, these Plugs are available with male thread only.

STABILIZER SUBS
Operators use these between the joints of Small-Diameter Pipe Strings to provide stabilizing shoulders that reduce friction on long cutting strings when working inside of internal flush pipe. (When working inside internal upset pipe, the upsets themselves provide stabilization and no stabilizing Subs are used.) These Subs are made of heat-treated and hardened alloy steel — and are sufficiently larger in diameter than the pipe to provide an elevator shoulder for supporting and handling the string. They are removed only when the pipe is used inside of other strings where clearance restricts the use of Stabilizer Subs.

Wide Adaptability Baash-Ross Small-Diameter Pipe Strings are unusually adaptable to virtually any small-pipe operation — for operating cutting strings, rotating small bits, clean-out tools, etc. . . . and they are the ideal pipe string to use with the popular Baash-Ross Power Swivel, which more and more operators are adapting to a wide variety of light rotating operations.

The Strings are externally flush, so can be run with complete safety inside all types of pipe — even internal upset pipe. They are available in a full range of sizes, but the most popular size is 1.660" in outside diameter. This size has the greatest range of adaptability since it can be run inside of any of the sizes of tubing or drill pipe indicated in the panel at left. ***Write for full details!***

The most popular size of Baash-Ross Small-Diameter Pipe—1.660" O.D.—can be run inside any of the following sizes of tubing or drill pipe . . .

TUBING:

2" E. U. or 2" Plain — and larger.

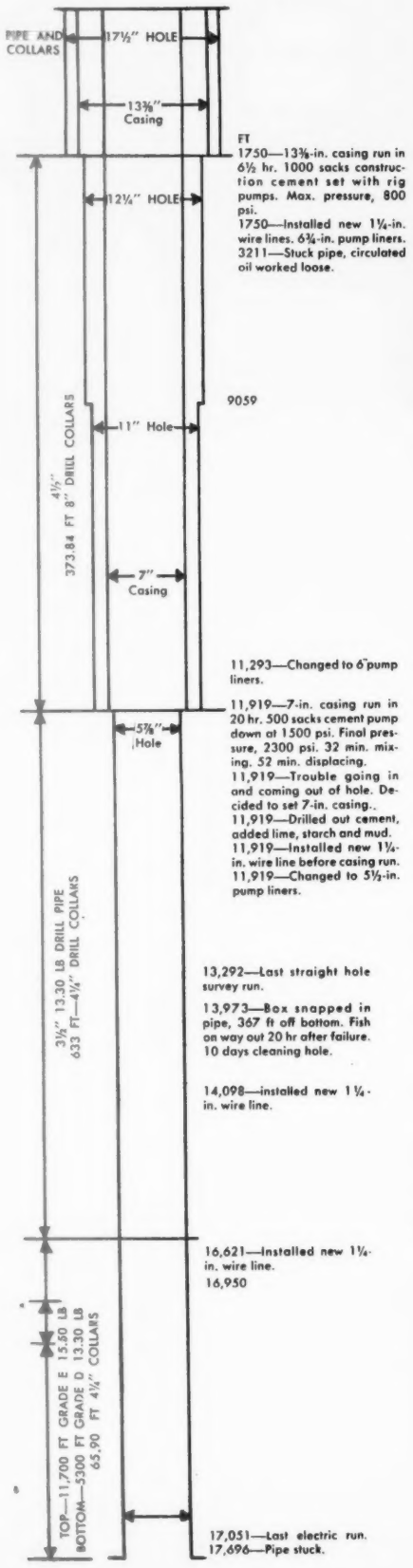
DRILL PIPE:

2⅜" A.P.I. "IF"
3½" A.P.I. "FH" and "IF"
4½" A.P.I. "Regular," "FH" and "IF"
5½" A.P.I. "Regular," "FH" and "IF"
6⅝" A.P.I. "Regular," "FH" and "IF"

Baash-Ross offers a complete range of Small-Diameter Pipe Strings for both sales and rental purposes. Prices, specifications and physical test data will gladly be supplied on request to our nearest office.

Rocky Mountain Drilling Company's drilling crew and Baroid's mud engineer: Keith Bright, engineer; Gilbert Cole, driller; Roy C. Bassett, cathead man; C. L. Moore, derrick man; and W. T. Elrod and Roy Cowan, floormen.

Below, casing program.


PIPE AND COLLARS
17½" HOLE
13⅜" Casing
FT
1750—13⅜-in. casing run in 6½ hr. 1000 sacks construction cement set with rig pumps. Max. pressure, 800 psi.
1750—Installed new 1¼-in. wire lines. 6¾-in. pump liners.
3211—Stuck pipe, circulated oil worked loose.
12¼" HOLE
9059
11" Hole
4½" 373.84 FT 8" DRILL COLLARS
7" Casing
11,293—Changed to 6" pump liners.
11,919—7-in. casing run in 20 hr. 500 sacks cement pump down at 1500 psi. Final pressure, 2300 psi. 32 min. mixing. 52 min. displacing.
11,919—Trouble going in and coming out of hole. Decided to set 7-in. casing..
11,919—Drilled out cement, added lime, starch and mud.
11,919—Installed new 1¼-in. wire line before casing run.
11,919—Changed to 5½-in. pump liners.
5⅞" Hole
3½" 13.30 LB DRILL PIPE 633 FT—4¼" DRILL COLLARS
13,292—Last straight hole survey run.
13,973—Box snapped in pipe, 367 ft off bottom. Fish on way out 20 hr after failure. 10 days cleaning hole.
14,098—installed new 1¼-in. wire line.
16,621—Installed new 1¼-in. wire line.
16,950
TOP—11,700 FT GRADE E 15.60 LB
BOTTOM—5300 FT GRADE D 13.30 LB
65.90 FT 4¼" COLLARS
17,051—Last electric run.
17,696—Pipe stuck.

depth and a deviation of only 2 deg at 13,292 ft.

Electric logs were run to a maximum depth of 17,051 ft but the results of these runs are not for publication. It is interesting to note, however, that no special troubles were encountered in the electric log surveys run below 17,000 ft.

Liberal use was made of an instrument for examining the drill pipe for progressive fatigue and rejection of used pipe on the basis of these inspections undoubtedly saved drill pipe failures while drilling. It is notable that only a single drill pipe failure occurred on the entire well and that was before the regular surveys were begun.

▸ **Mechanical failures.** There were but three mechanical failures in drilling Maxwell No. 1 and they were all overcome with but little lost time until the pipe stuck at the final depth. The first trouble developed while setting the 7-in. casing. When 11,877 ft of the total 11,919 ft had been set a joint of casing caught on the slips and the casing froze 42 ft off bottom before repairs could be made. This did not cause any lost time nor did it hinder the drilling program.

When making a round trip from a depth of 13,973 ft a box failed in the drill pipe when 367 ft off bottom. The fishing operations were carried on so efficiently that the fish was on the way out 22 hr after the failure. A 5⅞-in. by 6-ft outside cutter was run in on two 4¼-in. drill collars and between 2 and 3 ft of drill pipe was cut off on the first run. A 5⅞-in. socket with 3½-in. slips was then run and it took hold at 398 ft from the surface. The fish came loose with a pull of 30,000 lb above the normal weight of the fish.

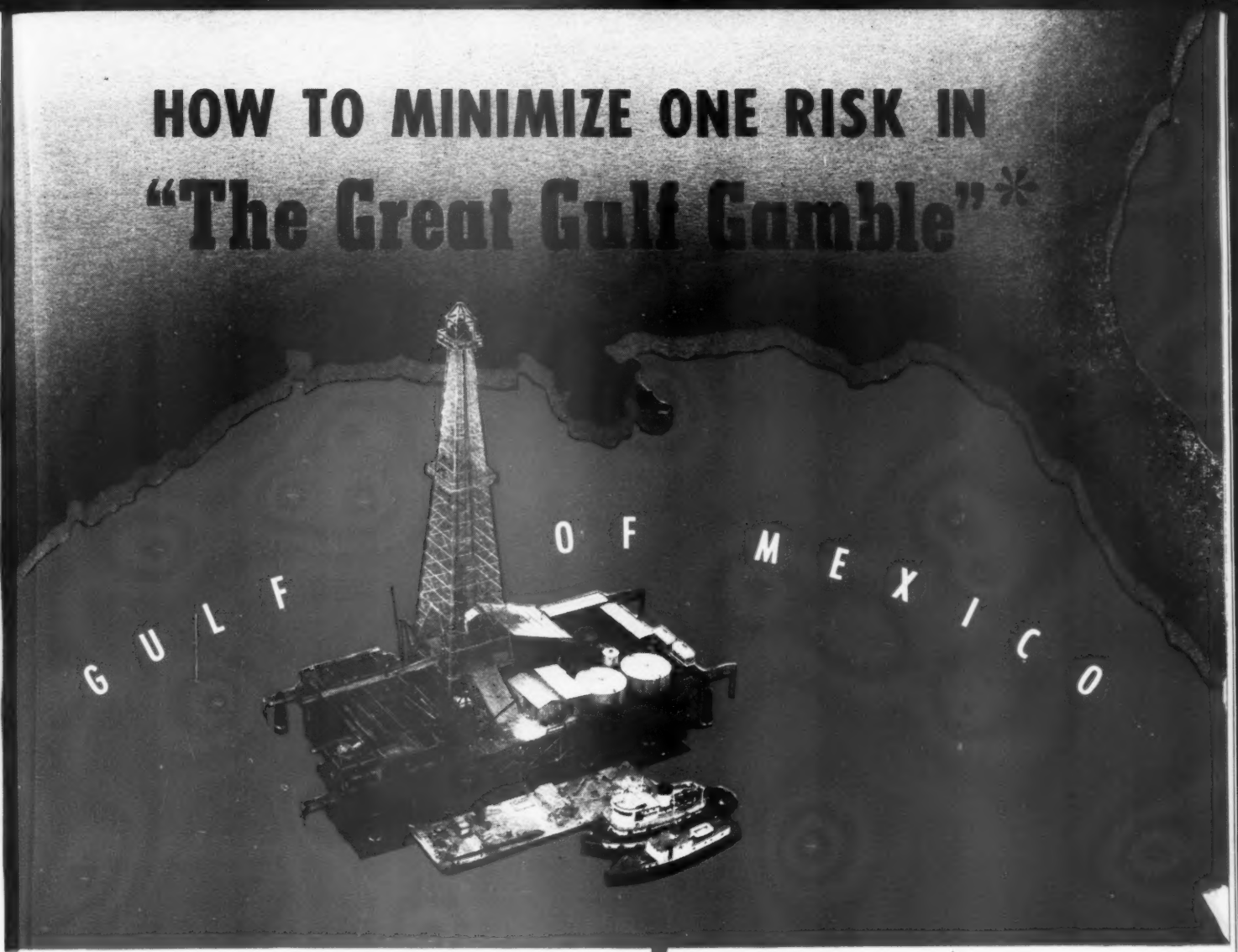
The third failure occurred after the well had been drilled to its total depth. The pipe hung up on what was probably a thick mud cake while trying to break circulation at a depth of 17,661 ft while going back into the hole after a routine round trip. Circulation was broken by the slush pumps after building up to 3000-psi pressure.

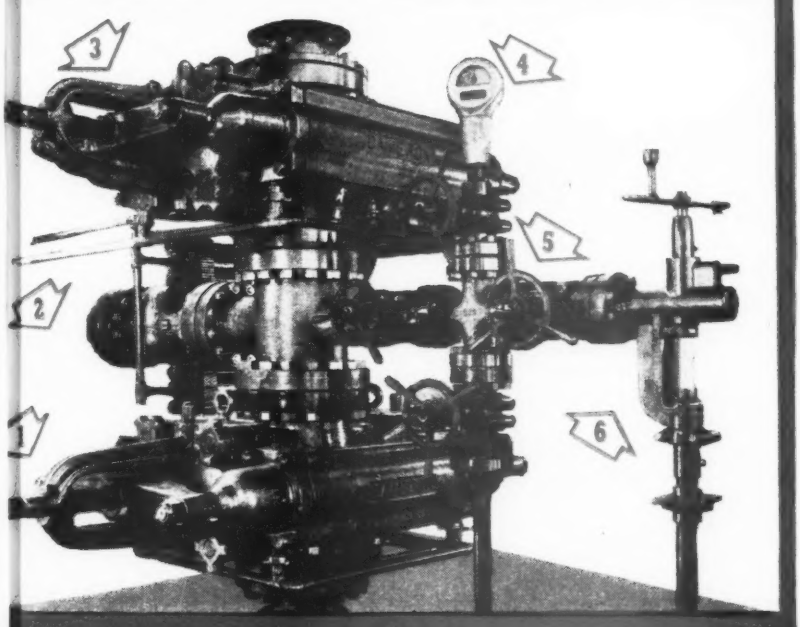
▸ **Effort to free pipe.** Every effort was made to free the stuck drill pipe by circulating various fluids. The first attempt was the immediate placing of 25 bbl of 21-gravity oil outside the pipe while working and rotating the pipe. Eleven cu ft of oil was pumped outside the pipe every 20 min and then the mud was changed to bring its weight up to 95 lb by adding 70 sacks of barytes. Circulation was maintained with the rig pumps for several hours before special cementing equipment was called onto the job. Pressures up to 4500 psi were encountered with the special equipment while spotting oil and circulating. The rig pumps were often working at pressures in excess of 2500 psi.

An oil base mud was made up from 750-lb pyrophosphates, 312-lb of 32-gravity oil, 50 bbl of 21-gravity oil, 970 sacks of barytes, and 50 lb of oil base material. This was circulated with the rig pumps but the pipe remained stuck.

Pulls were maintained on the stuck pipe while circulating. Several pulls of 300,000 lb were made although the pipe had an elastic limit of but 320,000 lb. Stretches up to 18 ft were produced and the measurements of elongation indicated that the pipe was stuck near the bottom of the hole. A 10,000-psi capacity cementing unit powered

HOW TO MINIMIZE ONE RISK IN "The Great Gulf Gamble"*





1 Cameron Type "QRC" Pressure-Operated Blowout Preventer, equipped with blind rams. 2 Cameron Type "HCR" Pressure-Operated Flowline Gate Valve. 3 Cameron Type "QRC" Pressure-Operated Blowout Preventer, equipped with pipe rams. 4 Cameron Mud Line Pressure Gauge. 5 Cameron Flex-Seal Mud Line Valves in mud choke manifold. 6 Cameron Type "D" Flow Wing in mud choke manifold.

* *See Fortune for July.*

While there can be no positive assurance that an offshore well will not blow out, most operators agree that the combination of Cameron Type "QRC" Pressure Operated Blowout Preventers, Type "HCR" Flow Line Gate Valves, and other safeguards that go to make up the modern drilling control assembly (left) will minimize that danger.

Due to the contemplated difficulties of coping with a wild well in the Gulf, some operators engaged in off-shore operations have resorted to the use of multiple (six or more) control units, i.e., two "QRC" Blowout Preventers equipped with blind rams, two with pipe rams, and two "HCR" Flow Line Valves, or combinations thereof, thus providing a first and second "line of defense" should well pressures become unruly.

Interested operators are invited to call on the nearest Cameron representative, or write for complete details.

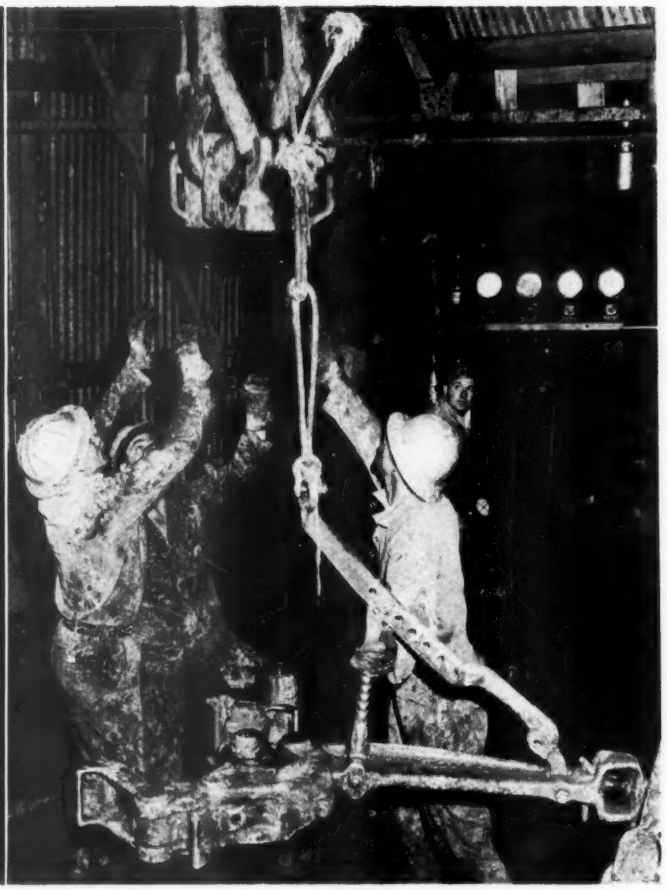
CAMERON

IRON WORKS, INC.

P. O. BOX 1212 HOUSTON, TEXAS

Export: 74 Trinity Place, New York, N. Y. Oklahoma: 310 Thompson Bldg., Tulsa (Telephone 28970). California: Long Beach (P. O. Box 267). Wyoming: 356 N. Wolcott St., Casper. North Louisiana: Bossier City (P. O. Box 425). Texas: Midland (Telephone 1982), Corpus Christi (Telephone 28783), Ft. Worth (Telephone 46522).

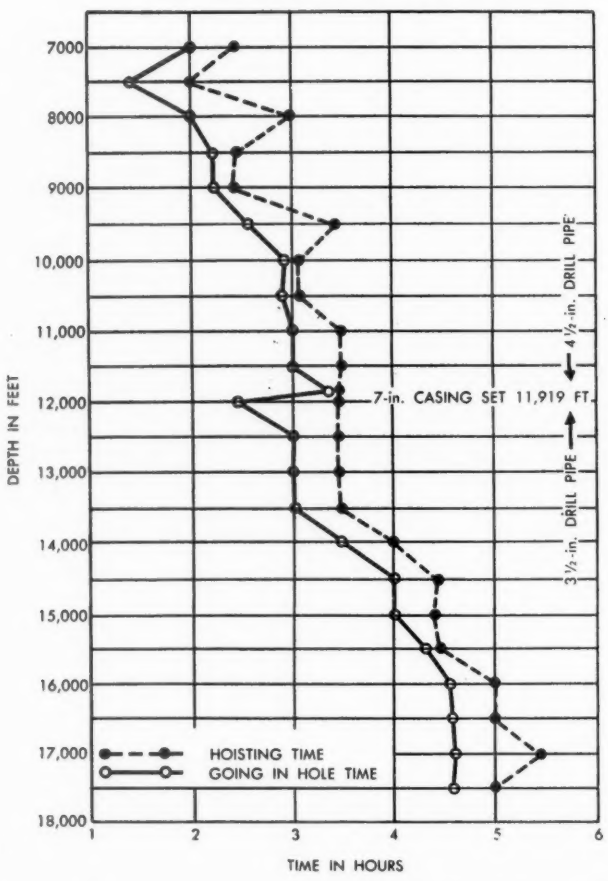
Driller J. G. Viles, Rocky Mountain Drilling Company, at the controls of Maxwell No. 1 draw works as drill pipe was being brought out of the hole. Note gauge showing almost 225,000 lb of drill pipe suspended in the hole. Well was bottomed at almost 16,900 ft at this time.



Coming out of the hole at 16,898 ft at Maxwell well.

Huge traveling block used in drilling Maxwell No. 1.

Hoisting and going-in-the-hole time.



Compare performance of....

CORING WITH DIAMONDS

IN THE WEBER SANDSTONE AT RANGELY

COMPARATIVE CORE RECORDS*

	DIAMOND HEAD	CONVENTIONAL BARREL AND BITS
Weber section cored (ft.)	485	433
Core recovery (ft.)	484.36	398.08
Core recovery (%)	99.89	91.93
Number cores cut	22	57
Average cut per core (ft.)	23.81	7.59
Total cutting time (hr.)	98.84	614.1
Total reaming time (hr.)	0	166.62
Total trip time (hr.)	143.9	675
Core time per foot (min.)	11.97	110.31
Number core bits	4	57
Avg. cut per head (ft.)	115.3	7.59

*Diamond-bit Coring, Neil Williams. *Oil & Gas Journal*, 1/4/47

THE WEBER IS TOUGH. The Weber sandstone at Rangely field in Colorado presented so many problems that until diamond coring was attempted, very little was known of the reservoir. The formation "is a thick section of very hard, fine-grained, tight sand interbedded with hard shale and lime and containing micaceous and arkosic depositions with a secondary cementation of calcite and silica."*

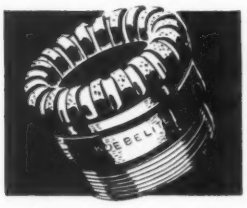
FOR BEST RESULTS, USE THIS MAGIC COMBINATION

KOEBELITE

DIAMOND INSERT CORE BITS

BLACK MAGIC

OIL BASE DRILLING FLUID



KOEBELITE CORING

reduces hours to minutes

Operators using Koebelite diamond core bits in the Weber made 11 cores in two wells for a total of 549 feet. Recovery was 100%. Core time averaged from 6.7 to 13.6 minutes per foot, where formerly footage had been computed in hours. Total diamond cost of the 549 feet was only $764.15 or $1.40 per foot.** Diamond coring programs required 6 to 8 days or one-sixth the time of conventional methods. Worn inserts can be replaced on Koebelite bits and many have cored over one thousand feet in the worst abrasive sands ever encountered.

**Drilling with Diamonds, H. C. Arnold, *Oil Reporter*, 4/20/48.

BLACK MAGIC

makes diamond coring possible

Because Black Magic oil base drilling fluid is not adversely affected by the reduced circulating rates required by diamond coring, it is now adopted as the standard medium in diamond coring programs. Mud conditioning is no longer necessary. Black Magic keeps a hole to gauge, another prime factor in successful diamond coring. It has a filtrate loss of zero in one hour on the API tester and will not damage or water block the producing section. Lubricating qualities of Black Magic save equipment, prevent fluid erosion on the matrix of Koebelite bits and prevent jamming of core barrels.

Coring the Weber by conventional means averaged 40 to 50 days. Conventional core bits were used up at an alarming rate. Time for coring one foot often ran over two hours. Frequent round trips slowed the program. Reaming was necessary. Costs were prohibitive. Something better was needed. Results of coring with diamonds have been tabulated in the above chart. Since then, many improvements have been added.

For complete information on coring with diamonds contact your nearest Oil Base, Inc., office or write the main office. Export representatives: Petro-Tech Service Company, Maracaibo, Venezuela; G. Saavedra E Hijos, S. de R. L., Mexico City, Mexico.

☆ ☆ ☆

OIL BASE, INC.

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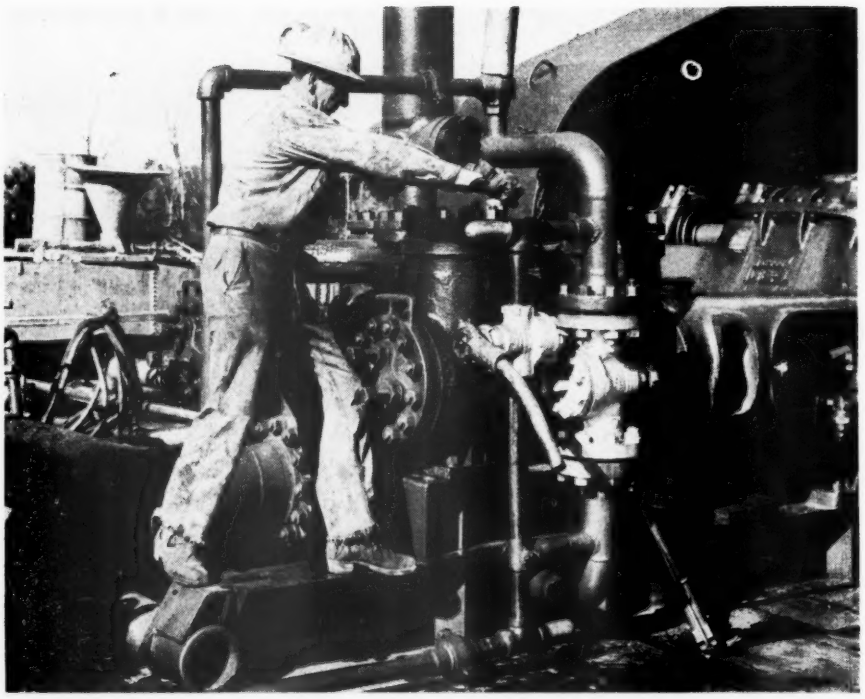
DISTRIBUTORS FOR KOEBELITE DIAMOND BITS

through a hydraulic torque converter was finally brought to the well to circulate 96-lb mud and 32-gravity oil. Pressures in excess of 5800 psi were built up in circulating with this equipment while holding a 280,000-lb strain on the pipe.

Five thousand gallons of acid was also pumped into the hole in an effort to cut the obstruction. This consisted of 28 per cent hydrochloric and 3 per cent hydrofluoric acids but they did not release the pipe.

Shooting below 16,000 ft. On January 6, twenty days after the pipe became stuck, the first try at shooting was made. The pipe was given 17 reverse turns and the slips were set with a 246,000-lb strain on the pipe. Two separate 40-ft long four-ribbon string shots with 100 grains of powder in each string were run on a braided cable to 17,520-17,560 ft. After attempts to fire they were pulled out and it was found that the caps had not fired, probably due to the extreme hydrostatic pressure.

The mud was then conditioned for 3 hr and a 1-in. by 12-in. torpedo shot was run to the collar at 16,802 ft. It was shot sucessfulyy but the pipe was not parted even though 19 reverse turns were taken. The pipe was worked with pulls of between 200,000 and 265,000 lb while conditioning the mud.



C. L. Horton, of Rocky Mountain Drilling Company crew, doing some maintenance work on the mud pump at Maxwell No. 1. Well was abandoned later when drill bit stuck at depth of 17,696 ft.

List of main items of equipment

Draworks—Type 125 Ideal Consolidated, with 40-in. hydromatic brake and sand reel, Foster spinning cathead, Foster master breakout cathead, BJ catline grip.
Drive—Ideal 4-engine chain type compound for four Superior engines.
Compressor—Gardner-Denver with two 5-hp General Electric motors.
Engines—4—PTD Superior, 6-cylinder diesels; 1—Le Roi 8.
Pumps—2—Ideal C-350; 1—Wilson Snyder 7P, 7¼ x 18.
Rotary table—Oilwell, 27½-in., with Varco Type A 27½-in. master bushing.
Shakers—2—Link Belt shale shakers.
Power slips—Byron Jackson.
Traveling block—Emsco Type M50-5.
Crown block—Reagan Type EB, 6 sheave.
Swivel—Oilwell 300 D.
Elevator—Byron Jackson, MDD with 2¾ x 108-in. links.
Kelly—Ideal 3½-in. square.
Air clutches—Fawick.
Indicators—Martin Decker weight indicator and troque indicator.
Wire rope—Pacific, for drilling and sand lines.
Mud hose—Goodyear.
Drill pipe—Spang-Chalfant 3½-in., 15.50, Grade E, EUIF.
Valves and seats—Eason Therolf, for mud pump.
Connector—Ideal DA-30.
Tongs—2—Byron Jackson type B.
Kelly bushing—Varco Type A.
Bits—Hughes OD, OWS, OSC 1, OSC 3; Reed 2 HM, 2T; Smith K 6, K 2 P, and Zublin diff.

Another 40-ft 4-ribbon shot was run to 15,480-15,520 ft and it was exploded with reverse torque and a heavy strain on the pipe. The ribbon shot exploded but the pipe did not come loose.

The next attempt was with a 1⅛-in. by 18-in. 1500-grain tropedo shot, which was sucessfully exploded at 14,690 ft but the pipe did not come free.

A 1¼-in. by 12-ft brass canister loaded with four quarts of nitroglycerine was run into the hole to 14,000-ft while holding 320,000-lb strain and 25 reverse turns on the pipe. There was no positive reaction to prove that the nitro had exploded so it was allowed to set until the temperature would be sure to cause the desired reaction. When the shot was pulled it showed that it had exploded. Circulation was broken at 1300 psi after this shot showing that the nitro had shot holes in the pipe at 14,000 ft.

Circulation was maintained for 1½ hr when another ribbon shot was run to 13,000 ft and exploded with 190,000-lb strain and 15 reverse turns on the drill pipe. The shot went off and the pipe was backed off successfully.

Fish left in hole. The top of the fish was at 12,972.46 ft after the drill pipe had been parted. This consisted of 154 joints (4622 ft) 3½-in. drill pipe, two 4¼ by 30-ft drill collars, one 4¼ double pin sub, and a 5⅞-in. tri-cone bit. This was cemented off with 30 sacks of high temperature cement before the hole was abandoned.

Conclusions. The Rocky Mountain Drilling Company and the Standard Oil Company of California did an outstanding piece of work in drilling Maxwell No. 1 to 17,696 ft with conventional power drilling equipment in record breaking time. This well showed that existing power pumps will stand up under the extreme pressures required to drill the deepest wells and the hoisting time with this equipment was comparable to conventional steam equipment.

Drilling conditions were favorable for this deep test but care in selection of equipment, frequent surveys to insure a straight hole, careful mud control, and close supervision resulted in a well that broke three world records and one California record. ★ ★ ★

Mud data.

Depth, ft	Circulating pressure, psi	Circulating volume, gpm	Hole size, in.	Pipe size, in.	Mud weight, lb./cu ft	Mud viscosity, API	Water loss, cc
12,000	1300	142	5⅞	3½	72	43	3.5
13,000	1500	140	5⅞	3½	77	46	2.5
14,000	1400	137	5⅞	3½	77	47	2.2
15,000	1500	131	5⅞	3½	78	50-60	2.5
16,000*	1500	130	5⅞	3½	79	50-55	2
17,000	1700	147	5⅞	3½	90	50-55	2.5
17,400	2000	150	5⅞	3½	91	55-60	3
17,700	2000	140	5⅞	3½	91-95	55-60	4

A "FIGHTIN' FOOL"

that "knocks 'em cold"

Drilling Contractors, Ltd., own this "Caterpillar" D8 operating in the Leduc (Canada) oil fields. Equipped with "Caterpillar" cable-controlled Bulldozer, Hyster winch, and a "home-made" rooter (projecting above bulldozer in illustration).

Tackling five feet of frozen earth on a slush pit job, this very tough "Caterpillar" Diesel wades in and knocks out its adversary in frozen chunks. With its "feet" (tracks) firmly planted, a ripping "left hook" (rooter) provides the opening, and a crushing "right" (bulldozer) sends things sprawling.

Only a tractor with the power and build of a "Caterpillar" Diesel can slug it out like that! And that goes for any kind of challenge the oil fields can throw in the ring. In addition to digging sump and slush pits, it can skid derricks, move drill rigs, mud pumps and engines. No wonder oil men regard a well-equipped "Caterpillar" Diesel Tractor as one of the handiest and most profitable tools they can own!

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Hydrocarbon absorption and fractionation process design methods

Par 16. Proposed Multicomponent Fractionation Calculation Method

By WAYNE C. EDMISTER*

EXCLUSIVE

In this chapter, the author's method of making multicomponent fractionation calculations to find the number of theoretical plates and component distribution will be presented, complete with equations, graphs, and illustrations.

The four previous chapters were devoted to multicomponent fractionation calculations; Part 12 *(The Petroleum Engineer*, April, 1948), covering the preliminary steps; Part 13 (June, 1948), covering the plate-to-plate methods; Part 14 (July, 1948), covering the minimum plates and reflux limits, and Part 15 (August, 1948), short cut methods. As has been previously pointed out, the preliminary steps, outlined in Part 12, are used with all methods, as are the minimum reflux and plate limits, presented in Part 14. Likewise, the plate-to-plate calculation methods, described in Part 13, may be applied as a final solution after an approximate solution by a short-cut method.

The use of more than one calculation method increases the design work involved. This additional work plus the fact that the designer must be familiar with two (or more) procedures, rather than one, makes it highly desirable to have one versatile calculation method that is reasonably short and at the same time fairly accurate. The development of such a method has been a challenge to chemical process design engineers for many years, as evidenced by the many articles that have been published on this subject (see references at end of Part 12). In all multicomponent fractionation calculation methods, except the plate-to-plate procedure, some simplifying assumptions are made in the development or application. These assumptions may be justified on some problems but not on others. There is no dependable method of telling which short-cut method may be used without undesirable inaccuracies for a given multicomponent fractionation problem. More skill and judgment are required in using the short-cut methods than the rigorous and longer plate-to-plate methods.

The difficulty with most short-cut methods is that average volatilities, and reflux quantities are used to reduce the calculations for several stages to an overall calculation. In some cases the proper average is near the low value and in others it is near the high value of the volatility or reflux ratio. With a logical and systematic method of finding the correct averages, a short cut method will give satisfactory results. The method described in this chapter is an overall equation method using effective absorption and stripping factors. As far as calculation time is concerned this proposed method might be called a short-cut procedure; however, the precision and versatility of this method puts it in the same category as the more rigorous methods just below the plate-to-plate methods. Thus, this proposed method is a rapid and fairly rigorous multicomponent fractionation calculation procedure.

The development of this proposed method followed the author's absorption and stripping calculation method summarized in Fig. 38 of Part 9. The effective absorption (or stripping) factor concept proposed in this previous method for absorbers and strippers was likewise used in developing the author's calculation method for fractionators. A review of Parts 5 and 9 would be helpful, but not essential, before studying the proposed method in this installment.

ANALOGIES BETWEEN FRACTIONATION and ABSORPTION STRIPPING

The author's absorption and stripping calculation method, summarized in Fig. 38 of Part 9, employed effective absorption and stripping factors that are unique functions of the terminal conditions, *i.e.*, top and bottom plates of absorber or stripper. As a fractionator may be considered as a combination absorber and stripper, with the absorber taking gas feed from the stripper and the stripper taking liquid feed from the absorber plus the fresh feed, the possibility of combining the equations for absorbers and strippers to obtain a calculation method is suggested.

This analogy is more clearly visualized by referring to Fig. 27 (Part 5) and Fig. 39 (Part 10), the first being a flow sheet of an absorption-stripping system while the second is a diagram of a fractionator. It will be noted that the plates are numbered in a consistent manner in each figure. The plates in both the absorber and in the enriching section of the fractionator are numbered from top to bottom, the top plate being "plate 1'" and the bottom plate being "plate n." Likewise, the plates in both the stripper and the stripping section of the fractionator are numbered from bottom to top, the bottom plate being "plate 1" and the top plate being "plate m". This analogy does not tell the entire story, however. The physical natures of these separation processes differ and, in addition, the mathematical expressions of the analogous processes differ.

In both absorbers and strippers low volatile solvent oil and high volatile gas are present. The same solvent oil passes through both towers while the gases are different, being the lean off-gas in the absorber and stripping-steam in the stripper. This presence of fluids of essentially zero and infinite volatility in both columns makes the absorber and stripper different from the corresponding sections of a fractionator. The extremes of volatility are not encountered in either section of a fractionator. Components of very low volatility appear predominantly in the stripping section, with small amounts on the lower plates of the enriching section. Likewise, components of very high volatility appear predominantly in the enriching section with small amounts on the upper plates of the stripping section.

Because of the presence of such large quantity of gas (wet gas or steam) in absorbers and strippers, the concentrations of solute in the vapor phase are referred to the entering gas (wet gas for absorbers and stripping steam for strippers). Likewise, concentrations of the solute in the liquid phase are referred to the lean oil for both absorbers and strippers. While this system of notation is most convenient for absorbers and strippers it is not workable for fractionators. For this reason, the equations developed for absorbers and strippers cannot be applied to fractionators. Different equations employing the same basic idea, namely; "effective L/KV and KV/L factors that are functions of terminal conditions and independent of the number of plates," have been derived for fractionators.[1, 2]

The first paper on this work, which appeared in 1946, presented the development of the equations and gave two alternate calculation procedures, the "series" method and the "short-cut" method. In the second publication on this method, empirical corrections for the short-cut effective absorption and stripping factors were proposed. The material presented in this installment will cover the material given in both of these previous publications plus addition explanations and examples.

*Carnegie Institute of Technology, Pittsburgh, Pennsylvania.

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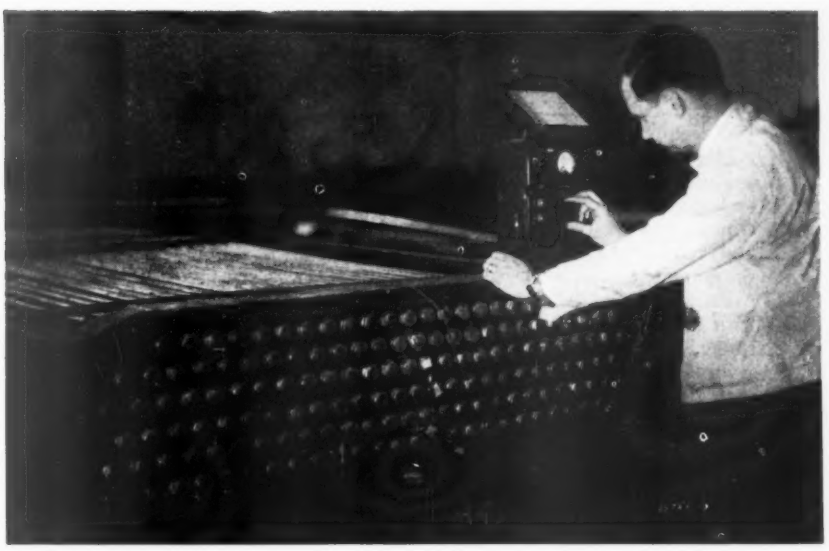

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FRACTIONATION EQUATION DEVELOPMENT

The development of the equations for the enriching and stripping sections of a fractionator is accomplished by considering the apparatus shown by Fig. 39 in Part 10, where there are "n" theoretical trays in the enriching section and "m" theoretical trays in the stripping section, the trays in each section being numbered from the tower top or bottom toward the feed plate. Any theoretical plate in the enriching section will be identified by the subscript "i", while any theoretical plate in the stripping section will be identified by the subscript "j".

The apparatus shown has a partial condenser and a kettle-type reboiler, so the reflux is the liquid in equilibrium with the distillate, while the vapor from the reboiler is in equilibrium with the bottoms product. Thus, the partial condenser and the reboiler are each another equilibrium stage. Although the equations are derived for a fractionator with these auxiliaries, the resulting method is applicable to other reboilers and condensers by slight modifications or by the proper interpretation of the results.

As customary in this type of derivation, each theoretical plate is considered an equilibrium stage with the vapor and liquid leaving in equilibrium, which equilibrium is expressed as follows:

$$K = y/x \text{ or } \frac{KV}{L} = \frac{v}{l}$$

These equilibrium relationships were presented earlier and used in previous equations. They will be used for both enriching and stripping equations.

The final equations will be expressed in component molar quantities in the same manner used in the Lewis-Mathison and Hummel methods in Part 13. In developing the equations for the proposed method it is most convenient to use mol fractions and then convert later to component molar quantities after the expressions are derived by substitutions and rearrangement of terms. The development technique is: (a) Make component material balance, (b) combine with equilibrium relationship and rearrange, and (c) repeat these two steps several times, including one more plate each time, thus expanding to the entire section.

In these equation developments, the subscripts define location. Each equation applies to any one component so no sub- or super-scripts need be used to designate component.

Enriching. A component material balance around the reflux separator (Fig. 39) is:

$$V_1 y_1 = L_d x_d + D y_d \quad . \quad . \quad . \quad (150)$$

Where:

V_1 = total mols of vapor leaving the top plate,

L_d = total mols of liquid reflux pumpback to the top plate,

D = total mols of distillate product,

y_1, x_d and y_d = mols fractions in respective streams; i.e. first tray vapor, reflux liquid and distillate vapor.

Dividing by V_1 and combining with equilibrium relationship $y_d = K_d x_d$ gives:

$$y_1 = y_d \left[\frac{L_d}{V_1 K_d} + \frac{D}{V_1} \right] \quad . \quad . \quad (151)$$

Combining equation (151) with equilibrium relationship $y_1 = K_1 x_1$ gives:

$$x_1 = y_d \left[\frac{L_d}{V_1 K_1 K_d} + \frac{D}{V_1 K_1} \right] \quad (152)$$

Writing a component material balance around the reflux separator and plate 1 gives:

$$V_2 y_2 = L_1 x_1 + D y_d \quad . \quad . \quad . \quad (153)$$

where the terms are the same as in equation (150) with different subscripts to denote different location.

Dividing equation 153 by V_2 gives:

$$y_2 = x_1 \frac{L_1}{V_2} + \frac{D y_d}{V_2} \quad . \quad . \quad . \quad (154)$$

Combining equations (152) and (154) to eliminate x_1 gives the following relationship:

$$y_2 = y_d \left[\left(\frac{L_1}{V_1 K_1} \right) \left(\frac{L_d}{V_2 K_d} \right) + \frac{D}{V_2} \left(\frac{L_1}{V_1 K_1} \right) + \frac{D}{V_2} \right] . \quad (155)$$

Combining equation (155) with the equilibrium expression $y_2 = K_2 x_2$ gives an equation similar to equation (152) but expanded to include one more plate:

$$x_2 = y_d \left[\left(\frac{L_1}{V_1 K_1} \right) \left(\frac{L_d}{V_2 K_d} \right) \frac{1}{K_2} + \frac{D}{V_2} \left(\frac{L_1}{V_1 K_1} \right) \frac{1}{K_2} + \frac{D}{V_2} \frac{1}{K_2} \right] . \quad (156)$$

A component material balance around the reflux separator and plate 2 gives:

$$V_3 y_3 = L_2 x_2 + D y_d \quad . \quad . \quad . \quad (157)$$

Dividing by V_3:

$$y_3 = x_2 \frac{L_2}{V_3} + \frac{D y_d}{V_3} \quad . \quad . \quad . \quad (158)$$

Combining equations (156) and (158) gives the following relationship for two plates plus a partial condenser:

$$\frac{y_3}{y_d} = \frac{1}{V_3} \left[\left(\frac{L_1}{V_1 K_1} \right) \left(\frac{L_2}{V_2 K_2} \right) \left(\frac{L_d}{K_d} \right) + D \left(\frac{L_1}{V_1 K_1} \right) \left(\frac{L_2}{V_2 K_2} \right) + D \left(\frac{L_2}{V_2 K_2} \right) + D \right]$$

. . . . . (159)

From equation (159) it is possible to write, by inspection, a general fractionation equation for an enriching section, expanded to "n" plates, where the ratio L/KV is defined as A, the absorption factor.

$$\frac{y_{n+1}}{y_d} = \frac{D}{V_{n+1}} [A_1 A_2 A_3 \ldots A_n + A_2 A_3 \ldots A_n + \ldots + A_n + 1] + \frac{L_d}{V_{n+1} K_d} [A_1 A_2 A_3 \ldots A_n] \quad . \quad . \quad (160)$$

Equation (160) is put into a more practical form by the following modifications:

(a) multiply through by $y_d V_{n+1}$

(b) substituting the equivalents: $v_{n+1} = y_{n+1}$ and $d = y_d D$

(c) defining:

$[A_1 A_2 A_3 \ldots A_n + A_2 A_3 \ldots A_n + \ldots + A_n + 1]$ as ϕ_1 (A)

(d) defining:

$[A_1 A_2 A_3 \ldots A_n]$ as ϕ_2 (A).

These changes give the following equation for the enriching section:

$$\frac{v_{n+1}}{d} = \left[\phi_1(A) + \frac{L_d}{D K_d} \phi_2(A) \right] \quad (161)$$

Where:

v_{n+1} = moles of any component in vapor going to the bottom plate of the enriching section,

d = moles of same component in distillate product,

ϕ_1(A) and ϕ_2 (A) = functions of L/KV for same component,

L_d = total moles of reflux liquid.

D = total moles of distillate,

K_d = vapor-liquid equilibrium ratio for component in question at the reflux condenser.

Equation (161) is an expression for the change in quantity of any component in going through the enriching section of a fractionator. The two ratios v_{n+1}/d and L_d/D are of particular interest. The first might be called the "enrichment" ratio because it is the ratio of the moles of any component entering the enriching section to the moles of the same component leaving as distillate. The second ratio is the reflux ratio. The ϕ_1 and ϕ_2 functions of A are dependent upon the number of plates, reflux ratio and the temperature gradient in a manner to be described later.

Stripping. In a similar manner the following analogous equation may be derived for the stripping section of a fractionator:

$$\frac{l_{m+1}}{b} = \left[\phi_1(S) + \frac{V_b K_b}{B} \phi_2(S) \right] \quad (162)$$

Where:

l_{m+1} = moles of any component in the liquid going to the top plate of the stripping section,

b = moles of same component in bottoms product,

ϕ_1(S) and ϕ_2(S) = functions of KV/L for same component,

V_b = total moles of reboiled vapor,

B = total moles of bottoms product.

K_b = vapor-liquid equilibrium ratio for component in question at the reboiler.

Equation (162) is an expression for the change in quantity of any component in going through the stripping section of a fractionator. The two ratios l_{m+1}/b and V_b/B are analogous to those in equation 161. The ratio l_{m+1}/b might be called the "depletion" ratio because it is a ratio of the moles of any component entering the stripping section to the moles of the same component in the bottom product. The ratio V_b/B is the boil-up ratio. The ϕ_1 ϕ_2 functions of S are likewise dependent upon the number of plates, boil-up ratio and temperature gradient in a manner to be described later.

A reference to Fig. 39 will make the

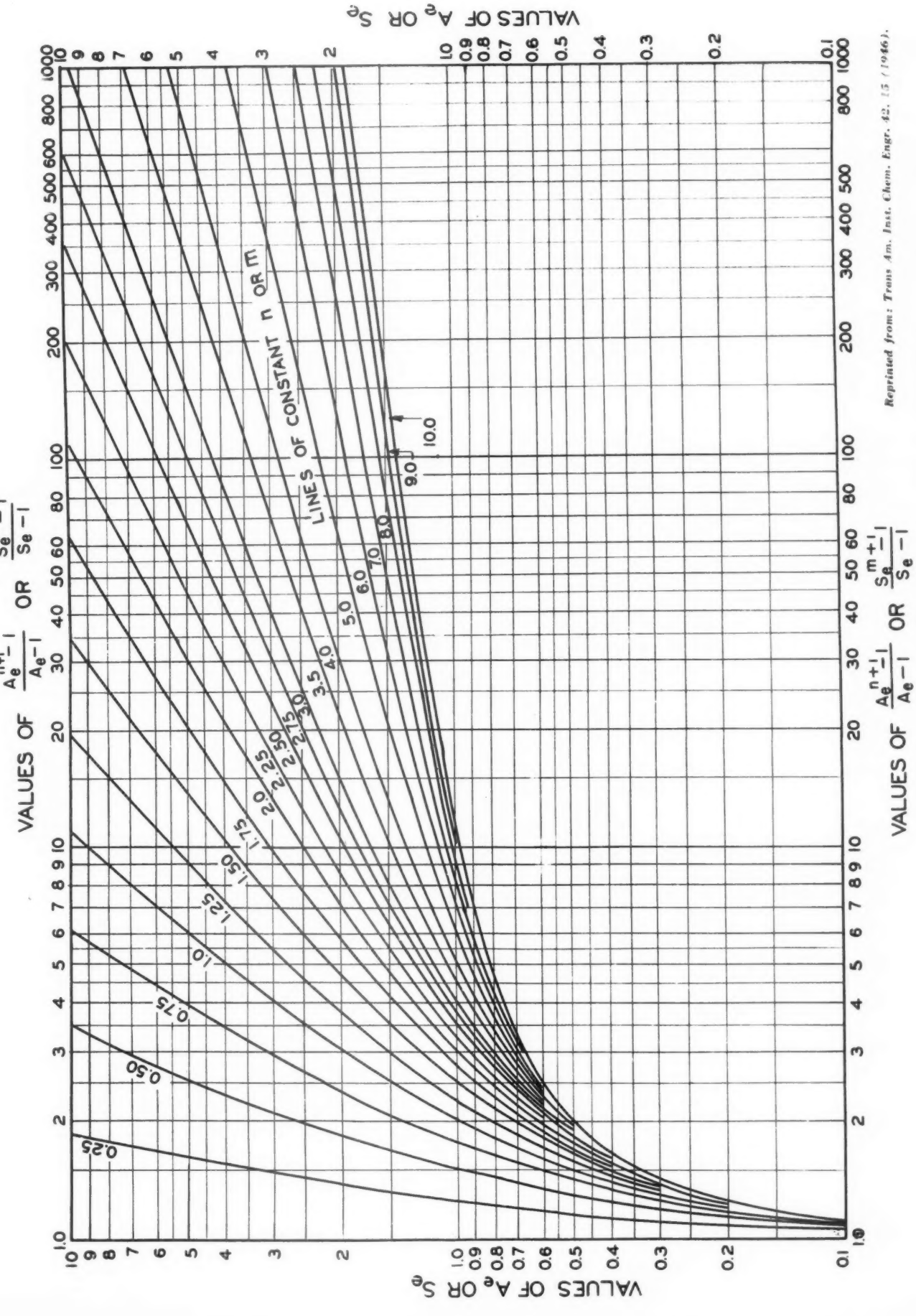

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FIG. 57. Effective absorption (A_e) and stripping (S_e) factor fun ction for Edmister multicomponent fractionation design method.

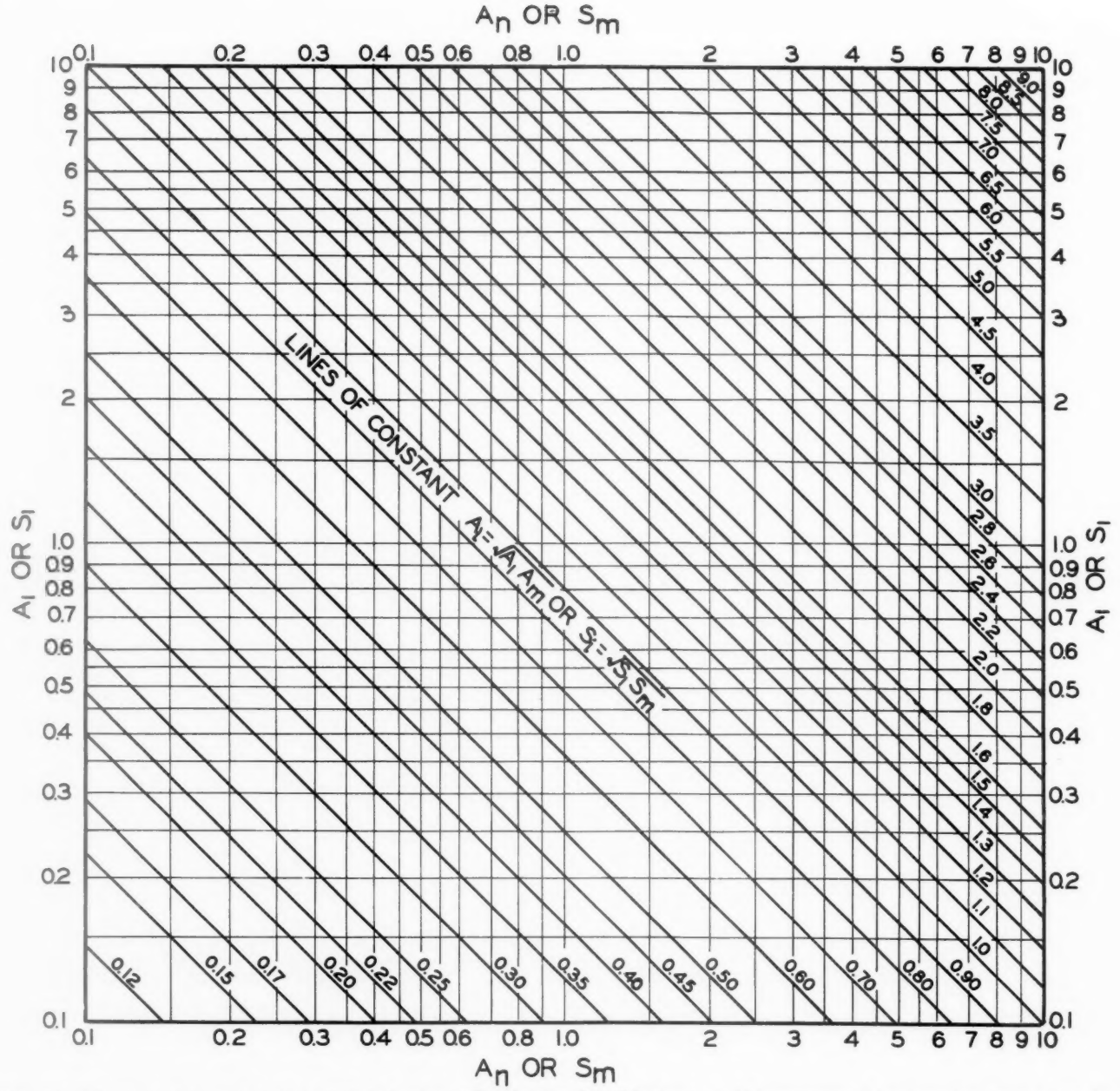

FIG. 58. Effective absorption (A_i) and stripping (S_i) factors for Edmister multicomponent fractionation design method.

significance of equations (161) and (162) more clearly understood.

Fractionation equations. By combining with feed plate material balance relationships, equations (161) and (162) are changed to expressions suitable for simultaneous solution without using feed plate compositions. Both equations are written in terms of v_{m1} the vapor from the feed plate.

If the fresh feed to the fractionator is at or between its boiling and dew points, but not below the boiling point or above the dew point, the relationship between the vapor leaving the stripping section and that entering enriching section is:

$$v_{n+1} = v_m + v_f \quad . \quad . \quad . \quad . \quad . \quad (163)$$

If the feed is at the boiling point $v_f = o$. If on the other hand, the feed is at its dew point, v_f equal the total moles of feed. Combining equations (161) and (163) gives:

$$\frac{v_m}{d} = \left[\phi_1(A) + \frac{L_d}{DK_d} \phi_2(A) \right] - \frac{v_f}{d}$$

$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (164)$$

When the feed is all vapor and above its dew point or all liquid and below its bubble point, a heat balance must be made around the feed plate to find v_m for this equation.

Equation (162) is likewise modified to include v_m by using the component material balance:

$$l_{m+1} = v_m + b \quad . \quad . \quad . \quad . \quad . \quad (165)$$

Combining equations (162) and (165) gives:

$$\frac{v_m}{b} = \left[\phi_1(S) + \frac{V_b K_b}{B} \phi_2(S) \right] - 1$$

$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (166)$$

Equations (164) and (166) are the fractionating equations of the author's proposed method. Two other procedures are required, in addition to these equations, namely: a technique for meshing the results at the feed plate and methods of evaluating ϕ_1 and ϕ_2 functions of A and S.

From equations (164) and (166) values of v_m/d and v_m/b may be found for each component, after the other terms have been evaluated in one of the three methods shown later. These ratios from the enriching and stripping equations are combined to give d/b as follows:

$$\frac{d}{b} = \frac{v_m/b}{v_m/d} \quad . \quad . \quad . \quad . \quad . \quad (167)$$

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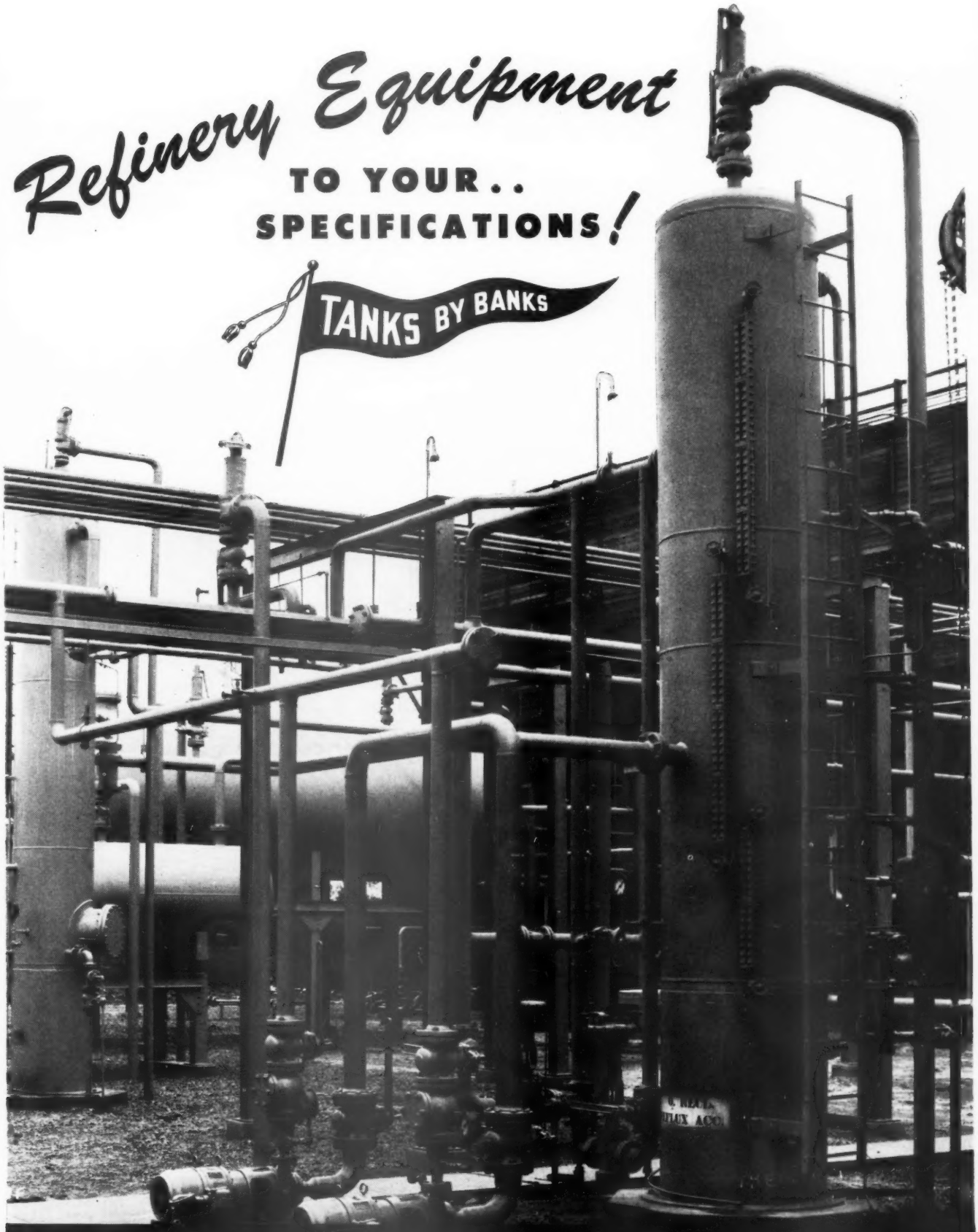

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component material balance to find the distillate and bottoms products.

By an overall component material balance:

$$b = \frac{f}{d/b + 1} \quad . \quad . \quad . \quad . \quad (168a)$$

$$d = \frac{f}{b/d + 1} \quad . \quad . \quad . \quad . \quad (168b)$$

Where: f, d, and b = moles of any component in feed, distillate and bottoms respectively.

From equations (167) and (168) it can be seen that the proposed method employs the same approach as the Thiele-Gedes and the Hummel method, *i.e.*, calculating the products for a given number of plates, reflux ratio, and temperature gradient.

EVALUATION OF FACTOR FUNCTIONS

There are three ways to evaluate the ϕ_1 and ϕ_2 functions of A and S. One is rigorous, one is an approximate short-cut, and one is a corrected short-cut. The rigorous method involves using the series expressions defining ϕ_1 and ϕ_2 directly. The short-cut method is based on effective absorption and stripping factors that are functions of terminal A and S valves, being independent of the number of plates. The corrected short-cut method uses corrected effective factors, the corrections being obtained from empirical correlations. Each of the methods will be discussed.

Series procedure. The rigorous evaluation of the ϕ_1 and ϕ_2 functions of A (or S) requires using the values of A (or S) for each plate in the following expressions:

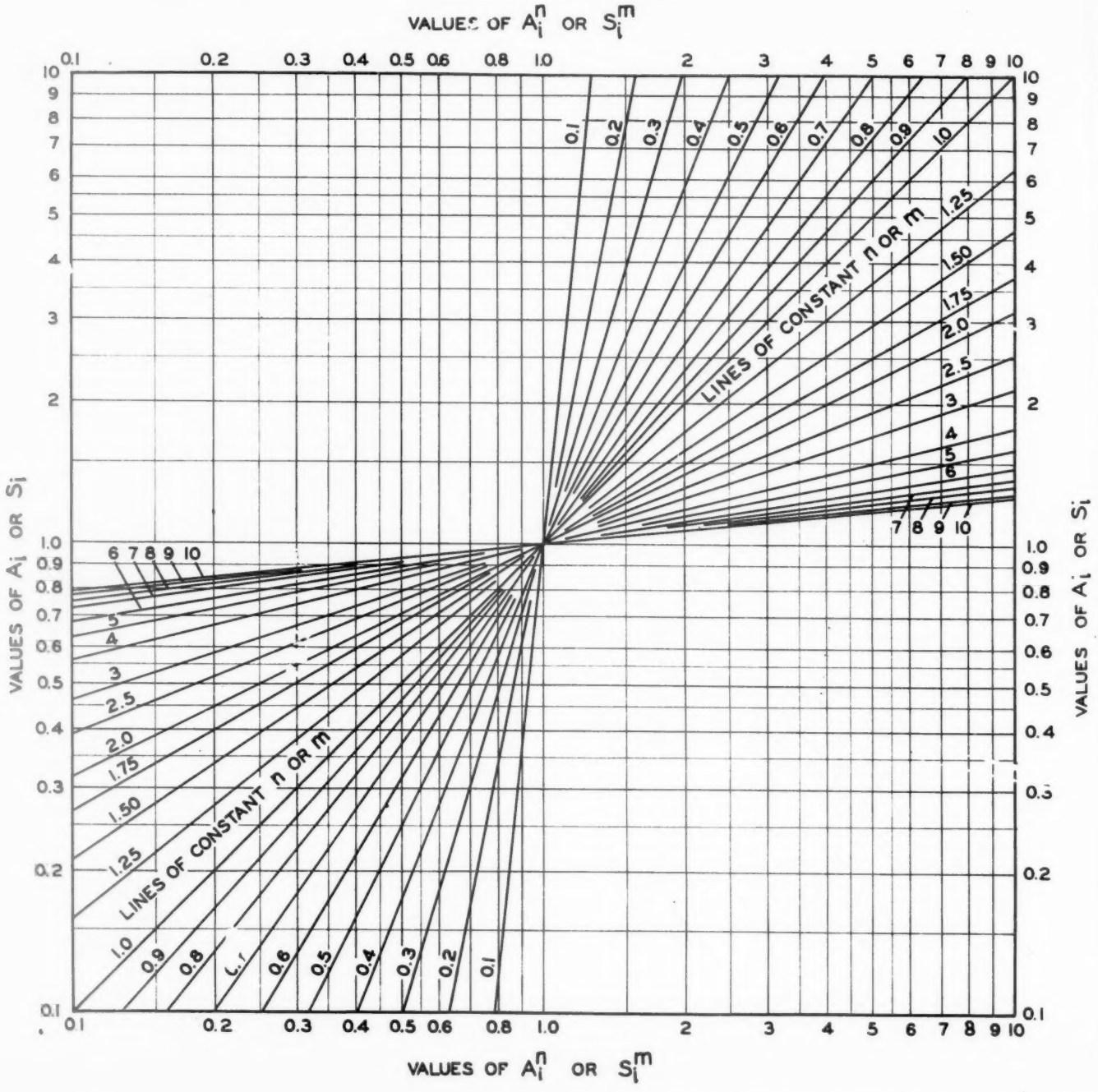
$$\phi_1(A) = A_1A_2A_3 \ldots A_n + A_2A_3 \ldots A_n + \ldots + A_n + 1 \quad . \quad . \quad . \quad . \quad . \quad (169)$$

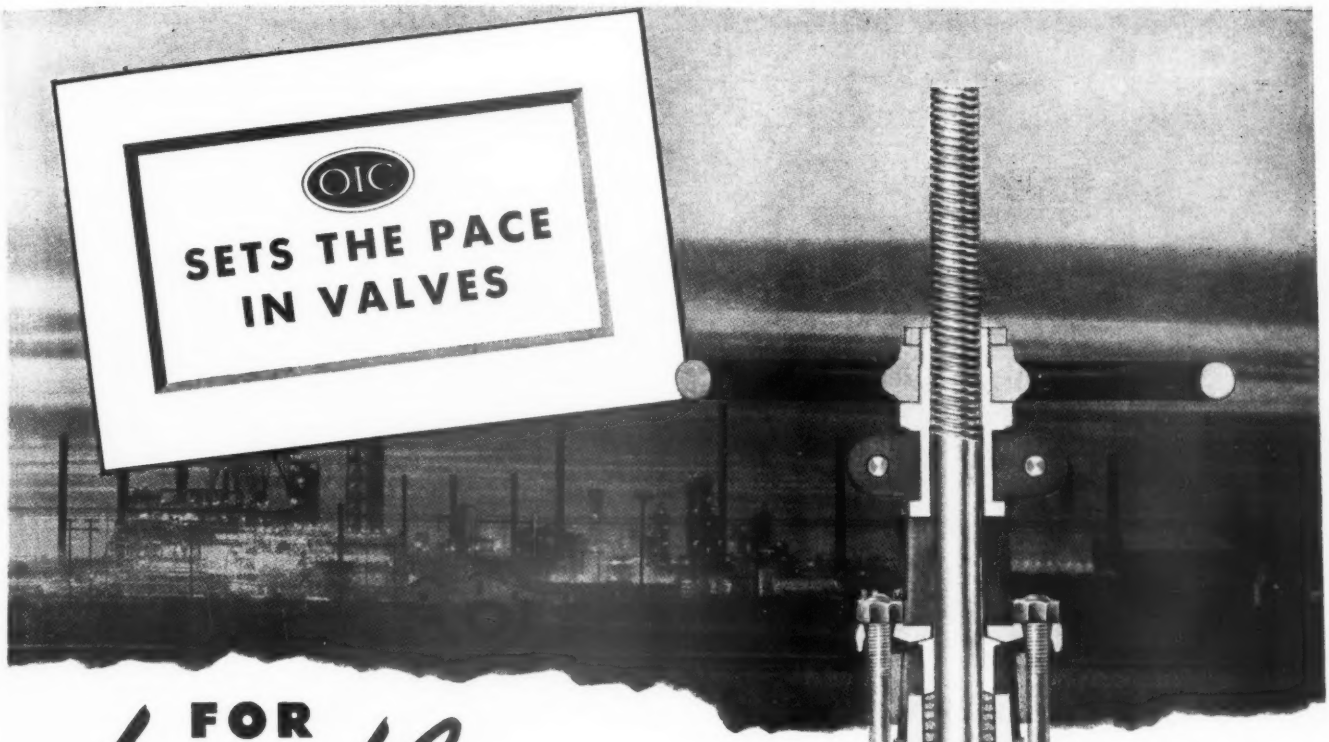
$$\phi_2(A) = A_1A_2A_3 \ldots A_n \quad . \quad . \quad . \quad (170)$$

The series equations for stripping are analogous to these for enriching. Equations (169) and (170), and the analogous equations for stripping, are used to evaluate the functions for equations (164) and (166).

Short-cut procedure. In most cases effective values of the A and S factors may be used in applying the fractionation equations. If the effective factors are defined with the above series equa-

FIG. 59. Effective absorption (A_i) and stripping (S_i) factor function for Edmister multicomponent fractionation design method.





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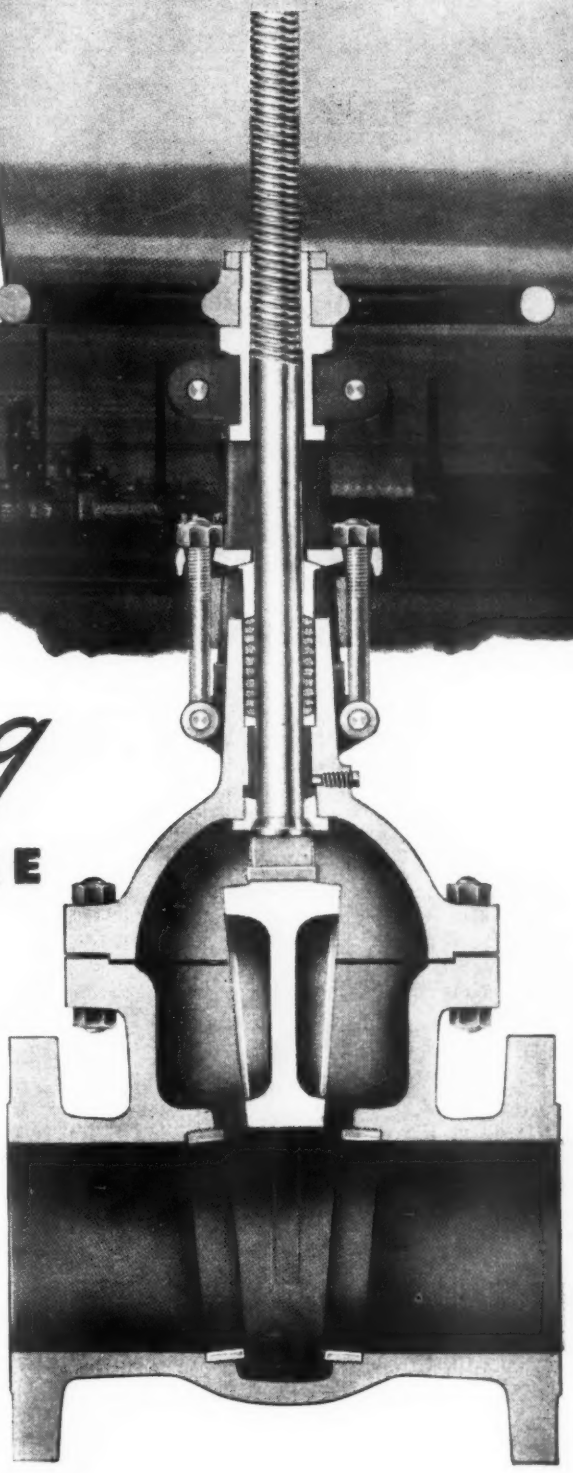

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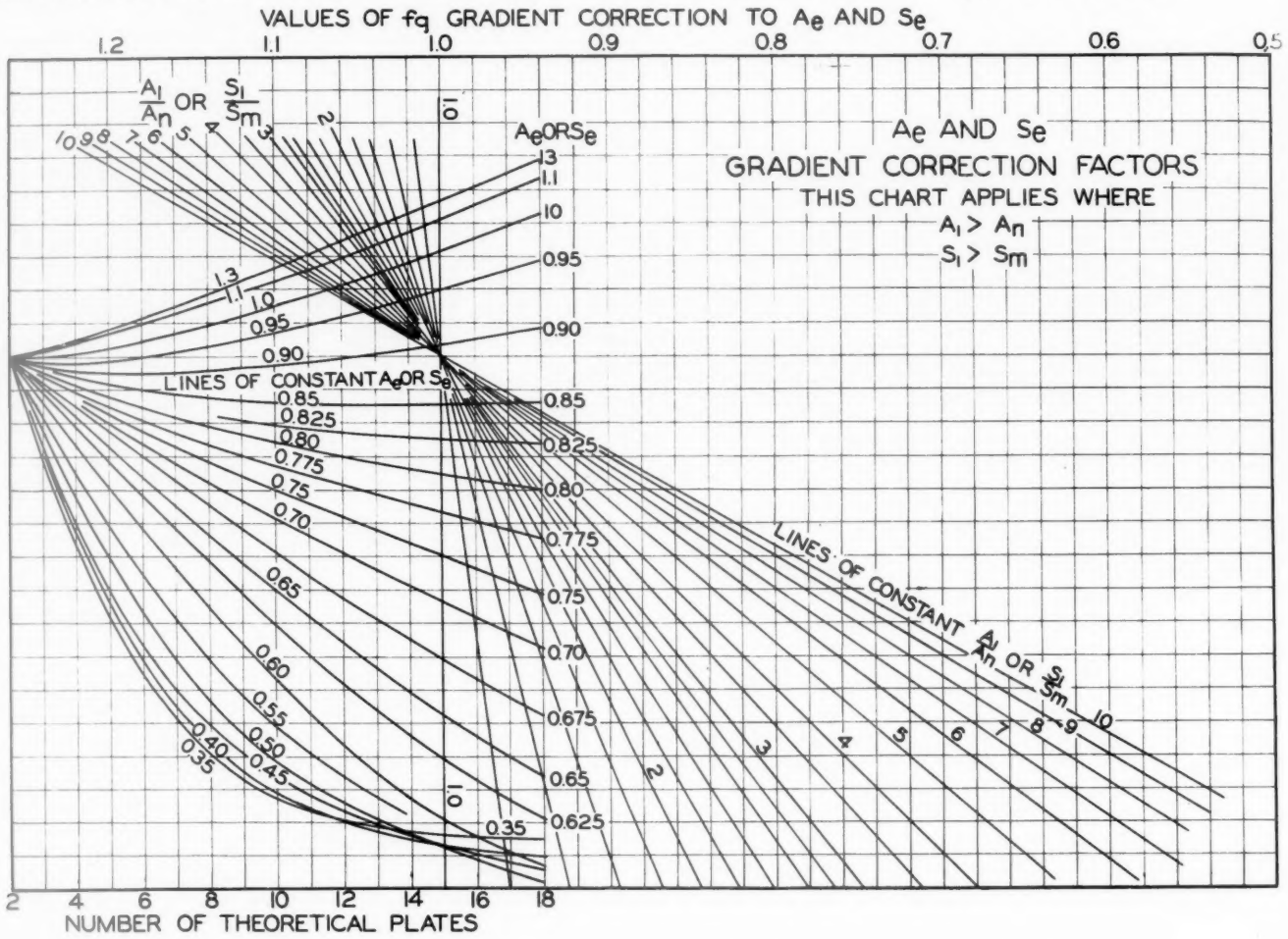
FIG. 60. Empirical gradient correction factors for effective absorption and stripping factors (A_e and S_e) from Equations 59 and 60 (Part 5), Fig. 29 (Part 5), or Equation 176, this installment. Use this graph when $A_1 > A_n$ or $S_1 > S_m$.



tions in mind, simplified mathematical expressions result.

Using an average or effective value of the absorption factor, which will be called A_e, in place of the individual plate values of A in equation (169), permits writing this series as one simple equation, which expresses the definition of A_e better than words, as follows:

$$\frac{A_e^{n+1}-1}{A_e-1}=\phi_1(A)=[A_1A_2A_3\ldots A_n+A_2A_3\ldots A_n+\ldots+A_n+1]. \quad (171)$$

Likewise, another effective A is defined by the following expression to cover the term given by equation (170), as follows:

$$A_1^n=\phi_2(A)=A_1A_2A_3\ldots A_n \quad (172)$$

If these two effective absorption factors, A_e and A_1, can be estimated, then the functions may be evaluated and the fractionation equations solved. It will be recalled that one of these effective factors, namely A_e, is the same effective factor used in the absorption design method, developed in Part 5 and summarized in Part 9. The same subscript is used because the equation to be derived for this effective factor is the same as the one found in the absorption equation derivations. This will be evident as the balance of the equation developments are presented.

Effective stripping factors are defined

FIG. 61. Empirical gradient correction factors for effective absorption and stripping factors (A_e and S_e) from Equations 59 and 60 (Part 5), Fig. 29 (Part 5), or Equation 176, this installment. Use this graph when $A_n > A_1$ or $S_m > S_1$.

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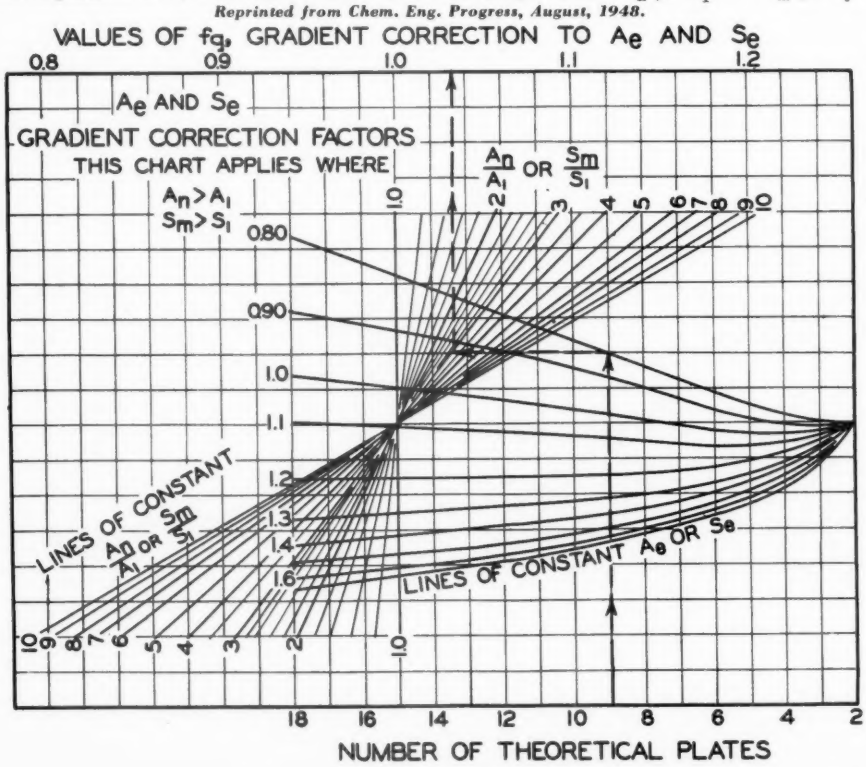

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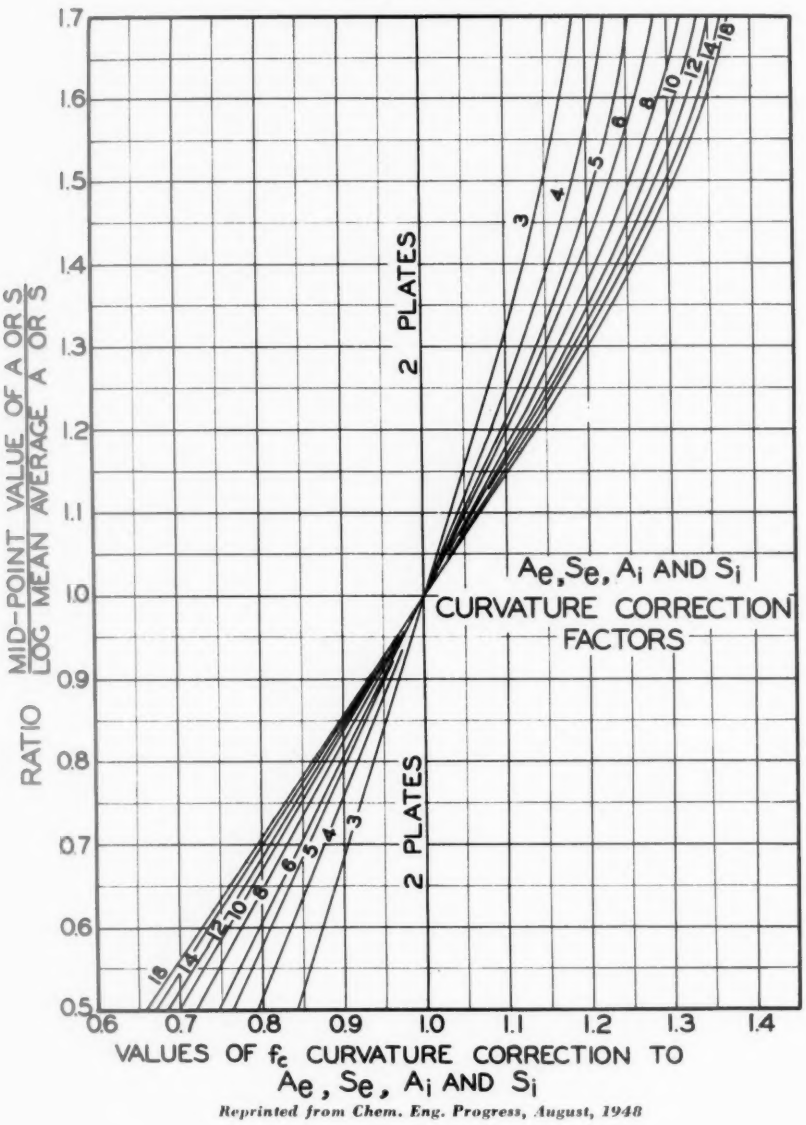
FIG. 62. Empirical curvature correction factors for effective absorption and stripping factors.



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in the same way by analogous equations to equations (171) and (172).

If the effective absorption and stripping factors may be assumed independent of the number of plates and therefore functions of the terminal conditions only, simple expressions may be derived for A_e and A_i. If A_e and A_i are independent of n, equations (171) and (172) may be written for a two-plate enriching section, as follows:

$$\frac{A_e^3-1}{A_e-1}=A_1A_n+A_n+1 \quad . \quad . \quad . \quad (173)$$

$$A_i^2=A_1A_n \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (174)$$

Equation (173) may be written:

$$A_e^3-A_e[A_n\ (A_1+1)+1]+$$
$$A_n(A_1+1)=0 \quad . \quad . \quad . \quad . \quad . \quad (175)$$

Equation (175) is identical to equation (57) (in Part 5) for which the solution was shown to be:

$$A_e\sqrt{A_n(A_1+1)+0.25}-0.5 \quad . \quad (176)$$

An analogous equation may be written for the effective stripping factor by inspection.

Fig. 29 in Part 5 is a graphical solution of equation (176), giving A_e as a function of A_1 and A_n, the terminal values of the absorption factor. With A_e (or S_e) it is a simple manner to evaluate $\phi_1(A)$ by equation (171), or Fig. 57, which is a plot of:

$$\frac{A_e^{n+1}-1}{A_e-1} \text{ vs } A_e \text{ and n,}$$

and also $\dfrac{S_e^{m+1}}{S_e-1}$ vs S_e and m.

The slide-rule evaluation of this function is simple so Fig. 57 may be considered an illustration of the function to show the effects of the independent variables, A_e and n (or S_e and m).

The other effective absorption factor, Ai, is found by solving equation (174), giving

$$A_i=\sqrt{A_1A_n} \quad . \quad . \quad . \quad . \quad . \quad . \quad (177)$$

Fig. 58 is a graphical solution of equation (177). This graph is really not required in solving equation (177). Fig. 58 was included in order to complete the graphical representation of the three effective factors; A_e, A′ and A_i the first two being represented by Figs. 29 and 30 in Part 5. A comparison of these three graphs is of interest.

With A_i, from equation (177) or Fig. 58 $\phi_2(A)$ can be evaluated by equation (172) or Fig. 59, which is also of more illustrative value than for use in design calculations.

Corrected effective factors. In developing equations (176) and (177), it was assumed that A_e and A are independent of the number of plates. This simplifying assumption is not always justified and yet the series method of evaluating ϕ_1 and ϕ_2 is too time consuming. Accordingly, the series and the short-cut gradients to develop empirical correction factors for the short-cut evaluation of more precise effective factors to use in equations (171) and (172).

The corrections for the effective factors A_e and A_i, from equations (176) and (177), may be found for any given A vs n curve by comparing equations (171) and (176) for A_e and equations (172) and (177) for A_i. This was done for numerous hypothetical cases and empirical correlations developed for the correction terms. This work was described recently by the author.[2] The empirical correlations for these correction factors are given in Figs. 60, 61, and 62, which were prepared in the following manner (although the "A" factor is used in explanation, the discussion applies equally to the "S" factor):

Several A vs n plots were constructed with several terminal values (A_1 and A_n) being selected so as to cover the probable ranges for the two cases; $A_1>A_n$ and $A_1<A_n$. These values of the terminal values were such that the ratios A_1/A_n and A_n/A_1 varied from 1.0 to 10.0. With terminal A values thus selected, A vs n curves were drawn straight, concave and convex on semi-log graph paper (A on log scale). In this way several families of hypothetical A vs. n curves were obtained. The abscissa of each of these plots was labeled with four plate number scales, i.e. 3, 5, 9, and 17. This procedure gave 10 graphs with 3 curves and 4 plate number scales, making 120 hypothetical A vs n (or S vs m) gradients in all. These arbitrarily constructed A (or S) factor gradients were used in a calculation program to develop the correction factor correlations shown in Figs. 60, 61 and 62.

For these hypothetical gradients the values of A_e, A_e corr., A_i and A_i corr. were found. The uncorrected values of A_e and A_i were found directly from the terminal conditions (A_1 and A_n) by means of equations (176) and (177). The corrected values of these effective factors (A_e corr. and A_i corr.) were found by the series equations (171) and (172) so that the use of the corrected effective factors in the left terms of these equations would give the values of ϕ_1 and ϕ_2 found by the series terms of these equations.

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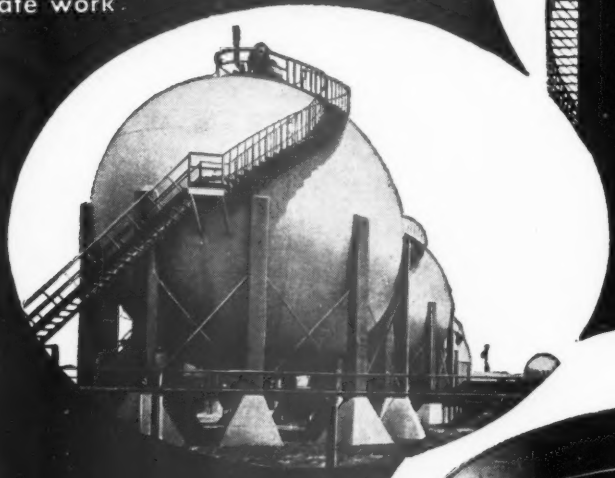

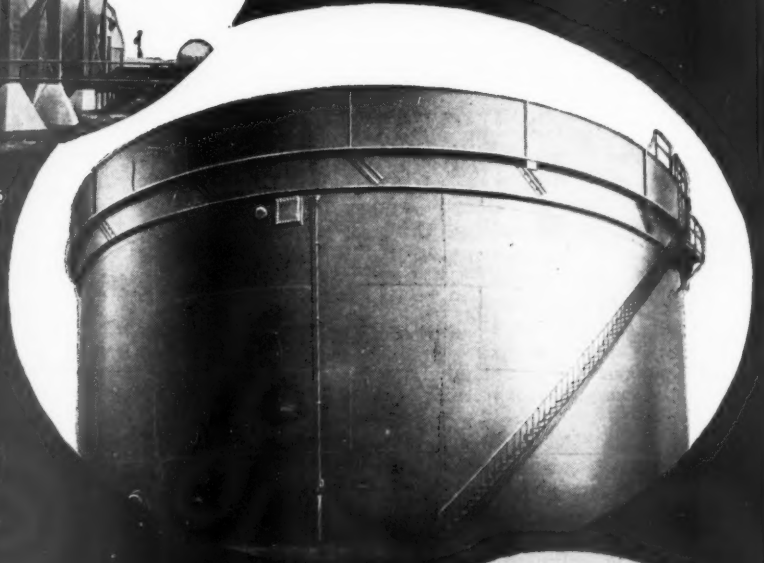

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This calculation program gave values of the short-cut and corrected effective factors for 120 hypothetical gradients. Next, empirical terms were devised to obtain the corrected effective factors from the short-cut values. This resulted in two correction terms, one for the straight (on semi-log scales) gradients and one for the curvature from a straight line. These correction terms are defined by the following equations:

$$A_e \text{ (corrected)} = A_e \times f_g \times f_c \quad . \quad (178)$$

$$A_1 \text{ (corrected)} = A_1 \times f_c \quad . \quad . \quad (179)$$

Where A_e and A_1 are the shortcut effective values found from equations (176) and (177), respectively.

The gradient correction term, f_g, is obtained from Fig. 60 or 61, depending upon the relative values of A_1 and A_n. It will be noted that f_g is a function of the number of theoretical plates and the terminal values of A, while the curvature correction term, f_c is a function of the number of theoretical plates and the departure from a straight line. The departure from a straight line is expressed by the ratio:

$$\left[\frac{\text{mid-point value of A or S}}{\text{log mean average A or S}}\right]$$

The numerator of this ratio is found by estimating the K values and L and V quantities at the mid point. The denominator is a function of the terminal values only.

Dashed examples show Figs. 60 and 61 are read. Examples will illustrate the application of these correction terms.

APPLICATIONS OF PROPOSED METHOD

The application of the author's proposed method by the three different procedures will be illustrated by examples, using the same problem solved in the previous examples. For the application of the "short-cut" method, with effective A and S factors from equations (176) and (177) or the graphs of these equations, the data given in Tables 55 and 57 of "preliminary steps" (Part 12) is sufficient. For the application of the "corrected effective factor" and the "series" methods, it is necessary to have intermediate values of the A and S factors. These may be estimated by the procedure suggested by Hummel and illustrated in Example 29 of Part 13 (see Tables 66 and 67).

In these examples, the calculations will be made only for the distributed components, propane and butane, using the same number of theoretical plates found in the plate-to-plate examples, namely; 9 in the stripping section and 6 in the enriching section.

Examples 39, 40, and 41. Using data from previous examples, including Tables 55, 57, 66, and 67, solve the depropanizer problem of previous examples by the three procedures of the author's proposed method. These three examples will be solved together after evaluating the ϕ_1 and ϕ_2 functions.

Example 39. Find ϕ_1 and ϕ_2 functions by series method. From Tables 66 and 67 the values of A and S are found for each plate and listed below:

Enriching factors, A			Stripping factors, S		
Plate	Propane	Butane	Plate	Propane	Butane
1	0.790	2.000	1′	1.620	0.879
2	0.715	1.700	2′	1.515	0.820
3	0.683	1.590	3′	1.450	0.777
4	0.633	1.440	4′	1.392	0.744
5	0.578	1.285	5′	1.352	0.718
6	0.513	1.080	6′	1.272	0.674
			7′	1.218	0.641
			8′	1.143	0.600
			9′	1.070	0.555

Next, the values of the ϕ_1 and ϕ_2 functions are evaluated for propane and butane for both sections, using the A and S values above and equations (171) and (172).

Enriching section

	Propane	Butane
A_6	0.513	1.080
A_6A_5	0.296	1.390
$A_6A_5A_4$	0.188	2.000
$A_6 \ldots A_3$	0.128	3.180
$A_6 \ldots A_2$	0.092	5.420
$A_6 \ldots A_1$	0.072	10.830
Σ	1.289	23.900
ϕ_1 (A)	2.289	24.900
ϕ_2 (A)	0.072	10.830

Stripping section

	Propane	Butane
S_9'	1.070	0.555
$S_9'S_8'$	1.223	0.333
$S_9'S_8'S_7'$	1.490	0.214
$S_9' \ldots S_6'$	1.896	0.144
$S_9' \ldots S_5'$	2.560	0.103
$S_9' \ldots S_4'$	3.560	0.077
$S_9' \ldots S_3'$	5.170	0.046
$S_9' \ldots S_2'$	7.830	0.049
$S_9' \ldots S_1'$	12.690	0.044
Σ	37.489	1.579
ϕ_1 (S)	38.489	2.579
ϕ_2 (S)	12.690	0.044

Example 40. Find ϕ_1 and ϕ_2 functions by short-cut method.

Enriching section (n=6)

	Propane	Butane
A_1	0.790	2.000
A_n	0.513	1.080
A_e (Eq. 176)	0.580	1.37
A_i (Eq. 177)	0.636	1.47
ϕ_1 (A) (Eq. 171)	2.28	21.9
ϕ_2 (A) (Eq. 172)	0.066	10.1

Stripping section (m=9)

	Propane	Butane
S_1'	1.620	0.879
S_m	1.070	0.555
S_e	1.248	0.636
S_i	1.315	0.700
ϕ_1 (S)	33.0	2.718
ϕ_2 (S)	11.8	0.040

Table 76. Calculations by three procedures of Edmister method.

Example no.	39		40		41 corrected	
Procedure	Series		Short-cut		Short-cut	
Component	Propane	Butane	Propane	Butane	Propane	Butane
Enriching section ($L_d/D = 90/59.9 = 1.50$)						
ϕ_1 (A)	2.289	24.90	2.28	21.9	2.25	24.0
ϕ_2 (A)	0.072	10.83	0.066	10.1	0.069	10.5
K_d	0.50	0.16	0.50	0.16	0.50	0.16
L_d/K_dD	3.00	9.39	3.00	9.39	3.00	9.39
$\frac{L_1}{K_dD}\phi_2$ (A)	0.216	101.8	0.198	94.9	0.206	98.5
$\left[\phi_1 \text{ (A)} + \frac{Ld}{K_dD}\phi_2 \text{ (A)}\right]$	2.505	126.7	2.478	116.8	2.456	122.5
v_f/d	0.73	30.0	0.73	30.0	0.73	30.0
v_m/d	1.775	96.70	1.748	86.8	1.726	92.5
Stripping section ($V_b/B = 83.9/40.1 = 2.09$)						
ϕ_1 (S)	38.489	2.579	33.0	2.718	38.6	2.605
ϕ_2 (S)	12.690	0.044	11.8	0.040	12.9	0.046
K_b	2.70	1.45	2.70	1.45	2.70	1.45
V_bK_b/B	5.66	3.04	5.66	3.04	5.66	3.04
$\frac{V_bK_b}{B}\phi_2$ (S)	71.8	0.134	66.8	0.122	73.0	0.140
$\left[\phi_1 \text{ (S)} + \frac{V_b K_b}{B}\phi_2 \text{ (S)}\right]$	110.289	2.713	99.8	2.840	111.6	2.745
v_m/b	109.289	1.713	98.8	1.840	110.6	1.745
Feed plate mesh						
$\frac{d}{b} = \frac{v_m/b}{v_m/d_f}$	61.6	0.018	56.2	0.021	64.1	0.019
$b = \frac{}{d/b+1}$	0.40	16.7	0.44	16.6	0.39	16.7
$d = f - b$	24.60	0.30	24.56	0.40	24.61	0 30

Example 14. Find ϕ_1 and ϕ_2 functions by the corrected short-cut, correcting the effective A and S values found in Exampe 40, using the mid points on the A and S curves from Example 39. Data appearing in the two previous tables will not be repeated.

Enriching section (n=6)

	Propane	Butane
A_1/A_n	1.55	1.85
f_g (Fig. 60)	0.967	1.013
A mid-point	0.657	1.52
A log mean	0.650	1.50
A mid/A log mean	1.012	1.012
f_c (Fig. 62)	1.006	1.006
A_e corr. $= A_e \times f_g \times f_c$	0.565	1.40
A_i corr. $= A_i \times f_c$	0.640	1.48
ϕ_1 (A)	2.25	24.0
ϕ_2 (A)	0.069	10.5

Stripping section (m=9)

	Propane	Butane
S_1'/S_m	1.51	1.58
f_g (Fig. 60)	1.015	0.96
S mid-point	1.352	0.718
S log mean	1.320	0.706
S mid/S log mean	1.024	1.019
f_c (Fig. 62)	1.01	1.015
S_e corr. $= S_e \times f_g \times f_c$	1.28	0.62
S_i corr. $= S_i \times f_c$	1.329	0.71
ϕ_1 (S)	38.6	2.605
ϕ_2 (S)	12.9	0.046

Using the ϕ_1 and ϕ_2 functions obtained by the three methods, the fractionation calculations for this separation are completed in Table 76 under the headings of Examples 39, 40, and 41.

Referring to Table 76, it will be noted that the results for the series (example 39) and corrected short-cut (example 41) methods are in agreement with the plate-to-plate results in Part 13.

For this separation the short-cut (example 40) is very close so the additional trouble of correcting the A and S factors is not justified.

For separations where there are three or more distributed component and not as sharp a split as this one, there will be more difference in the methods.

References:

1. Edmister, W. C., *Trans Amer. Inst. Chem. Engrs.* 42, 1, 15 (1946) 2, 403 (1946) and 4, 757 (1946).
2. Edmister, W. C., *Chemical Engineering Progress*, August, 1948.

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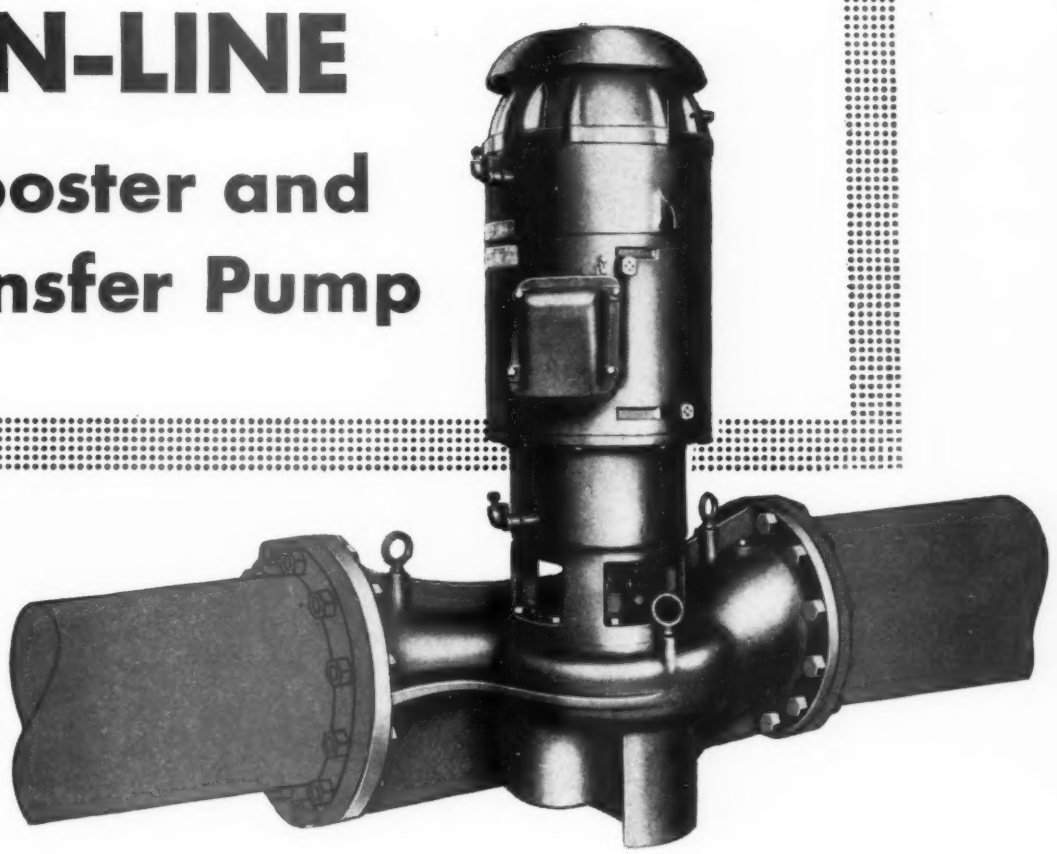

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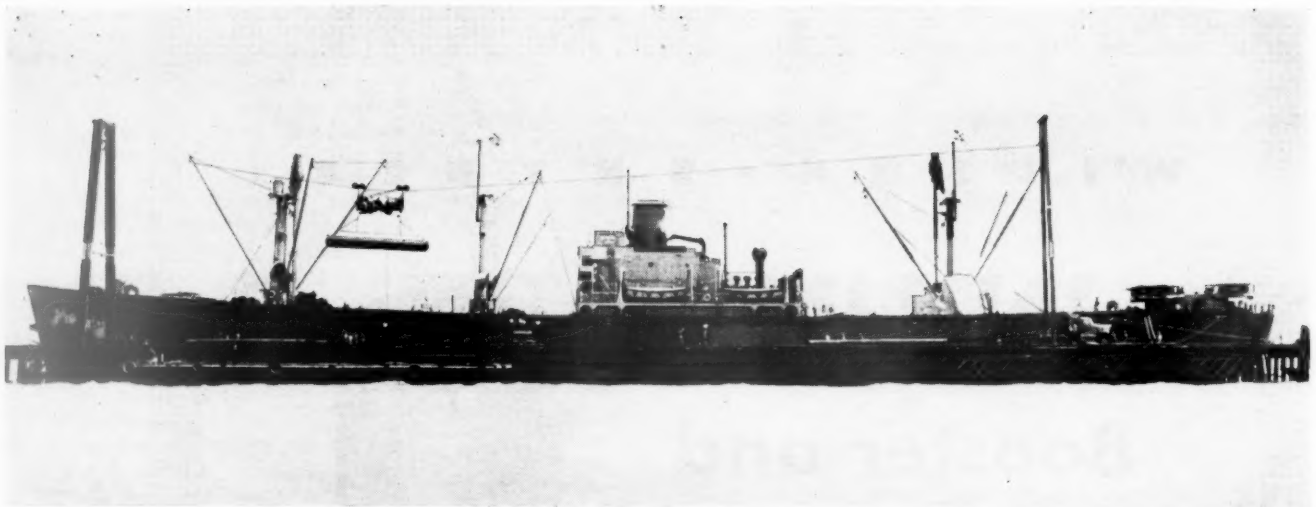
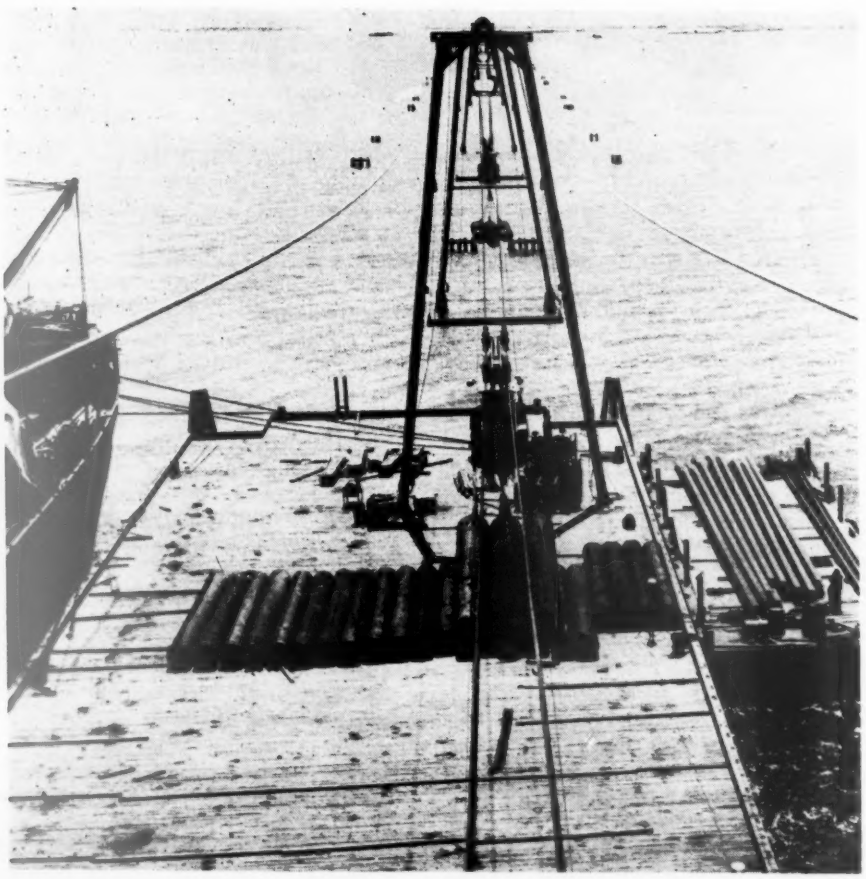


Cargo ship in Persian Gulf anchored alongside Trans-Arabian Pipe Line Company's sea island, showing device picking up 3 lengths of pipe, which it will carry 3 miles to shore. Below, overhead view of sea island 3 miles offshore from Ras El Misha 'ab, Arabia. One Skyhook heads inland with its 7½ tons of pipe and a second picks up its load.

Roadway in the sky



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*Developed and manufactured by Pointer-Willamette Company, Inc., of Portland, Oregon. The Skyroad track cables and Skyroad traction cables are products of John A. Roebling's Sons Company, Trenton, New Jersey.

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CAPACITIES: Up to 5000 gals. per hour

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PRESSURES: Up to 90 lbs.

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WATER LUBRICATED: OPEN LINE SHAFT CONSTRUCTION

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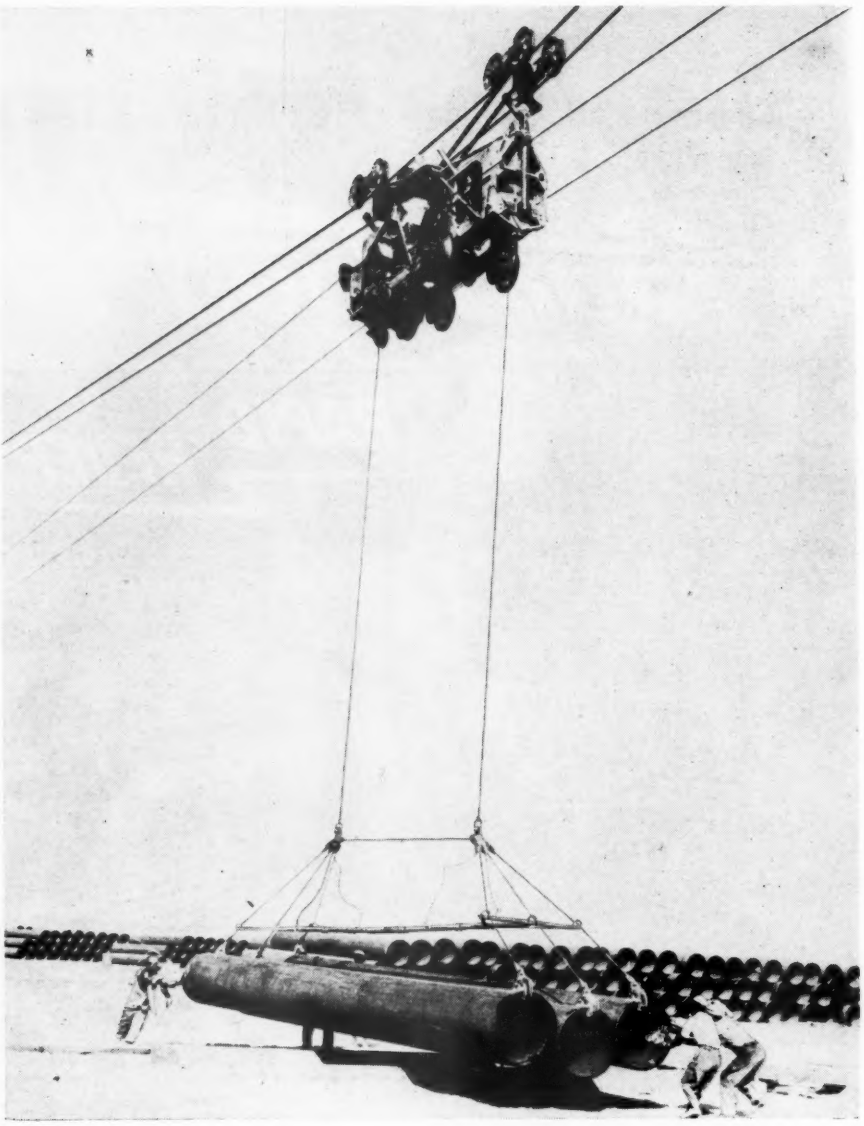


Skyhook lowering its 7½-ton load of pipe at the storage yard after carrying it over 3 miles of cableway in Saudi, Arabia, operations.

possible length of an installation of this kind. Spur skyroads can be erected to branch from the main road wherever desired. At points where the job requires working over a wide area, the skyroad can be suspended from lateral cables and thus moved from side to side.

The Skyhook itself is completely mobile and is driven to the job on its own tires. Anchored on blocks it acts as its own "rigging up" machine. While at work in the air, the operator rides in the carriage where he has full control of the machine's performance. As the weight of the traction cables is supported by the ground or cable supports, virtually the entire carrying capacity of the machine is devoted to the load alone.

There are several different models with load capacities ranging from 2 to 20 tons—all with speeds in either direction up to 35 mph. On operations involving the ordinary moving of materials, the rated capacity of the machine and of the cables chiefly determine the weight of the loads that can be carried safely. On jobs where the machine is employed as a crane, a far greater lifting capacity is obtainable by the use of rigging blocks or by other common techniques employed in moving heavy materials.

In addition, the equipment is exceptionally versatile—merely by changing the type of carrier it proves itself a "jack-of-all-trades". It can handle a skip, a clamshell bucket, or a dragline bucket. If the materials to be moved call for an electro-magnet, for a hook or tongs, a sling or a choker, the equipment works as effectively with one as with the other.

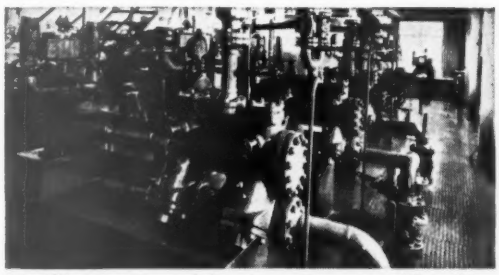
Mention has been made of the ease and low cost of moving a skyroad from one site to another. One owner in the United States dismantled his original 4000-ft installation, moved it one mile, and set it up again in about 500 man-hours with an inexperienced crew. More than 80 hr were consumed in carrying the assembly across a sizeable river.

* * *

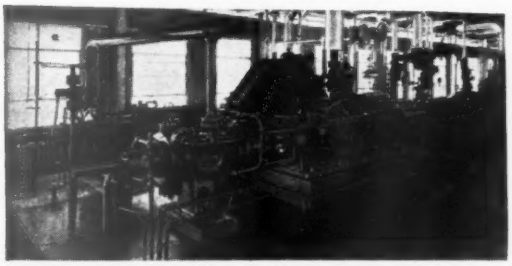
It Takes a Lot of Worthington Equipment to "Dry Out" Gas

These pictures show some of the Worthington equipment installed in The Chicago Corporation's Feazel & Kinsey gasoline plant located at Carthage, Texas, designed and built by Stearns-Roger Manufacturing Co. of Denver.

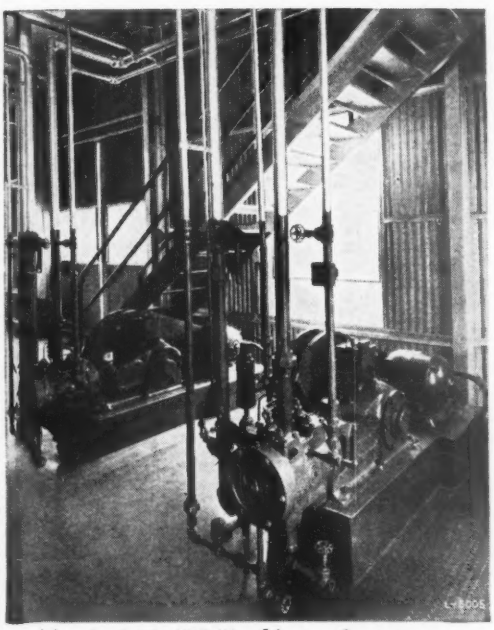
The purpose of this plant is to take the wet high-pressure gas produced from the high-pressure gas wells in the Panola County fields, and separate the water vapor from the recoverable hydrocarbon vapors consisting primarily of propane, butane, and gasoline. The residue dry gas leaving the absorbers is delivered to the pipe line for transmission and distribution.



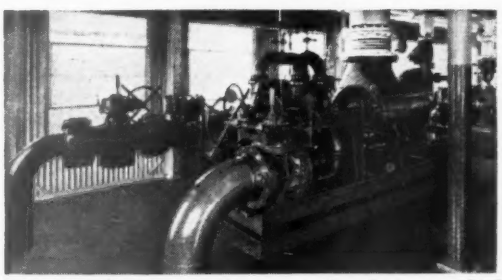
Worthington steam-driven process pumps, with turbine-driven centrifugal high-pressure lean oil pumps in background



Worthington type OXP single-stage steam-driven gas compressor used as vapor recompressor



Two 5 x 5 type HB Worthington Compressors supplying air to instruments



Two Worthington six-stage centrifugal pumps which supply absorption oil to the high-pressure absorbers at a discharge pressure of 1300 psi maximum. Each pump is driven by a 875 hp Worthington Multi-stage condensing steam turbine

Keeps Pressure on Oil Sands— Saves By-Passing Not-Needed Water

As you know, it is highly detrimental to permit variable pressure on oil sands. Any material reduction in pressure results in loss of oil production which may never be recovered.

On the Lawton Oil Company lease near Bradford, Pa., a Worthington Automatic Variflo (variable capacity) Power Pump is used for repressuring oil sands by water, and was selected for the purpose because it automatically compensates for withdrawals for other uses.

Water is taken from the discharge line between pump and input water well for house use, drilling operations, etc. The Variflo pump with its pressure governor automatically compensates for these variable withdrawals and maintains constant pressure on the oil sands.

The pump operates at 240 rpm with 500 psi discharge pressure.

The Variflo pump eliminates the necessity of by-passing high pressure water not required as the capacity pumped is automatically adjusted to the requirements of the system. By-passing liquid is inherently inefficient and the horsepower that would be wasted through by-passing is saved by using the Variflo pump, and in addition the efficiency of the Variflo pump remains high throughout its full capacity range.

2 x 4 Worthington Variflo Pump used in repressuring oil sands by water

NEWS

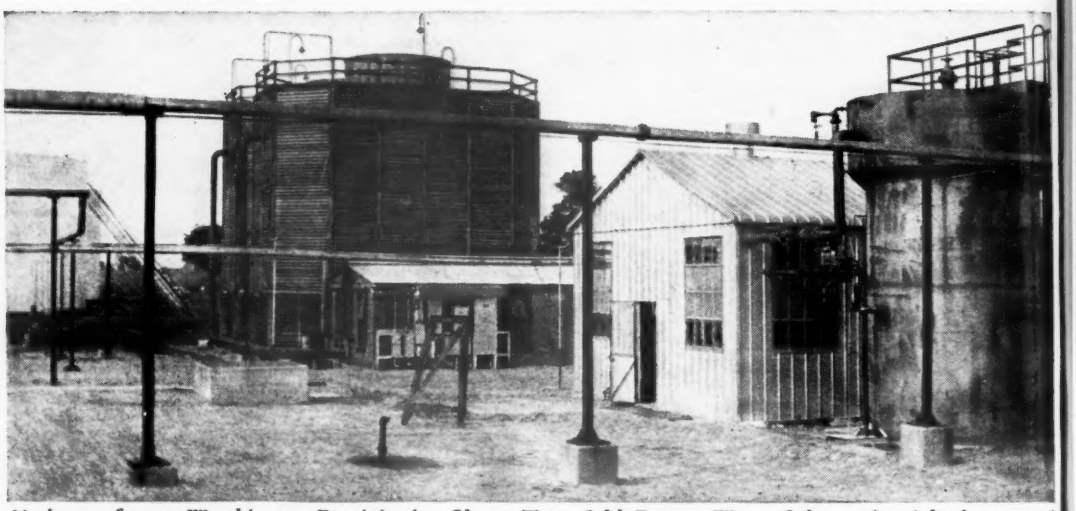
FROM THE PETROLEUM FRONT

AS REPORTED BY THE DEVELOPMENT ENGINEERS, FIELD SERVICE REPRESENTATIVES AND CUSTOMERS OF WORTHINGTON

NEWS

from the petroleum front

Worthington Water Softener Eliminates Scale and Corrosion



Modern refinery—Worthington Precipitating Slurry Type Cold Process Water Softener in right foreground; cooling towers in background

Scale and corrosion are prevented in the cooling water system of modern refineries by Worthington's exclusively-designed Precipitating Slurry Type Cold Process Water Softener. Continuous delivery of uniformly soft, stabilized, clear water is assured.

In this Worthington Water Softener, maintenance of the softener slurry bed is entirely accomplished by the scientific use of hydraulic energy provided by the pressure of the general raw water supply system.

This eliminates moving agitating parts formerly thought necessary for mixing the applied chemicals with pre-formed precipitate.

New Gas Compressors for Philadelphia Electric Co.

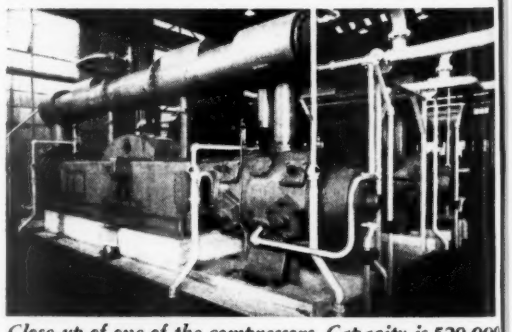
Demands for gas heat, for both industrial and residential use, have skyrocketed during recent years in Philadelphia. With the war's end, plans for enlargement of Philadelphia Electric Company's Chester gas plant were put into effect.

The excellent performance records of Worthington equipment—such as the 1400 hp horizontal twin-tandem two-stage gas engine compressors — suggested consultation with Worthington engineers, which led to the selection of more Worthington equipment to handle the requirements of the increased service load.

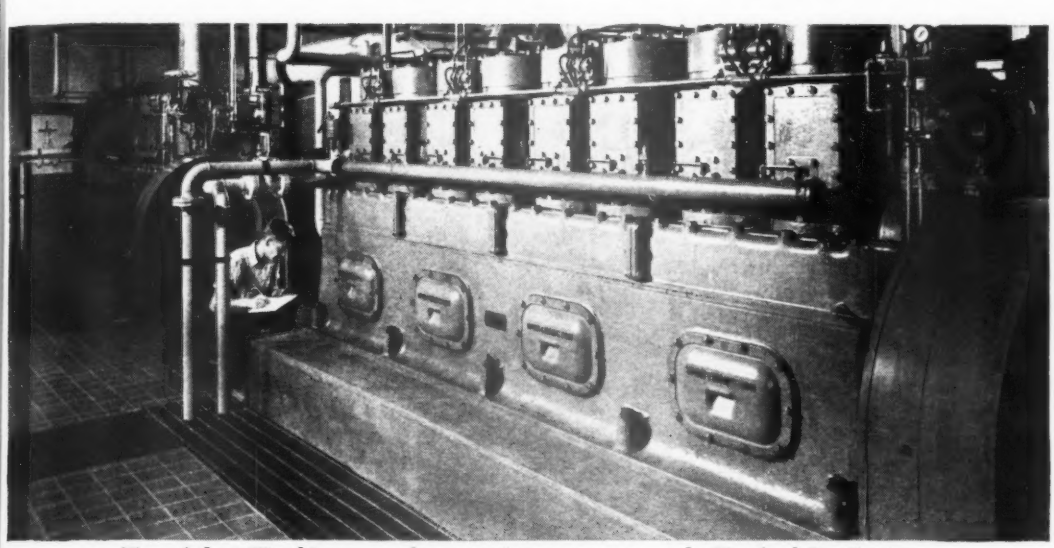
A 1750 hp motor-driven gas compressor was installed and has been in operation two years. A duplicate unit, for additional requirements, has been installed this year. Driven by synchronous motor, it is capable of delivering 520,000 cu ft of free gas per hour against a discharge pressure of 100 psi into the distributing system of gas mains.

Since the gas supply to this unit is being furnished from large steel gas holders, it was necessary that special precautions be taken, in the construction of this compressor, to minimize gas pulsations in the suction gas holder. As the result of special design of the gas cylinders, pulsation has been virtually eliminated even when operating at partial capacity.

2 Worthington 1750 hp motor driven gas compressors



Close-up of one of the compressors. Capacity is 520,000 cu ft of free gas per hour against a discharge pressure of 100 psi



Two of the 3 Worthington angle gas engine compressors at the Hartford Gas Company

One of New England's Finest Compressor Installations

The Hartford Gas Company, which celebrates its 100th Anniversary this year, supplies modern gas service to 63,000 customers in metropolitan Hartford and Manchester.

The Company purchases about two-thirds of its send out gas from coke ovens at New Haven and manufactures the rest as water gas in Hartford.

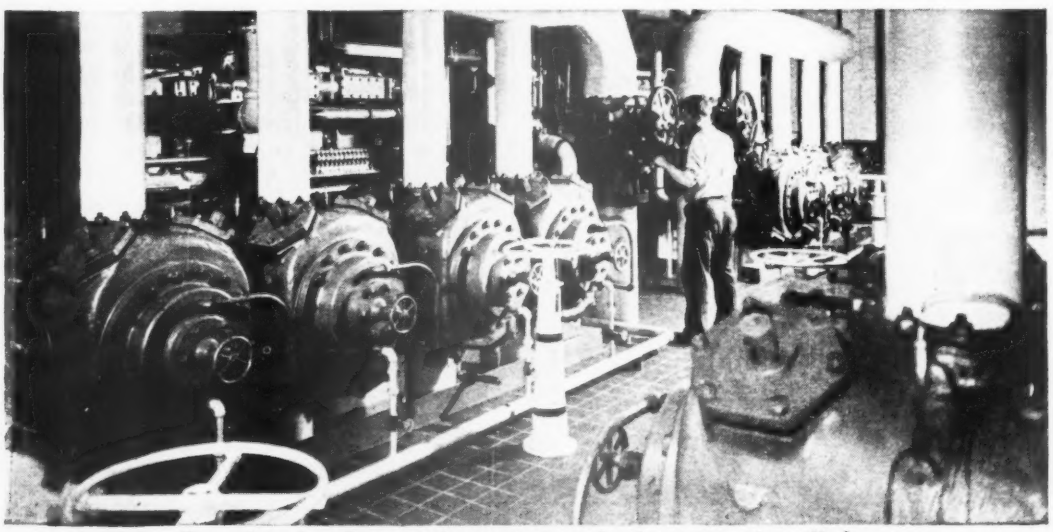
With a constant increase in gas sales, more and more of the send out has to be pumped through an intermediate pressure system.

To do the job, three Worthington LFC-8 angle engine compressors, each with eight power cylinders and four compression cylinders and each displacing 4653 cfm of a mixture of coke oven and water gas (equivalent to 225,600 cfh free gas capacity), are used.

This equipment is designed for operation normally at 25 lb gauge and, by a system of clearance pockets, to 50 lb for handling pipe line to Manchester, Connecticut in an emergency.

The photographs show why this installation has become a center of attraction for persons interested in gas distribution.

Interestingly, the coke oven gas brought from New Haven, some 35 miles away, is pumped by three other large Worthington compressors which have been in continuous service for 20 years.



Rear view of angle gas engine compressors showing compression cylinders

Worthington Pump and Machinery Corporation

•

Harrison, N. J.

Selective Acidizing With the Electric Pilot

JACK M. MOORE, Dowell Incorporated, and RAY E. KOLLAR, Gray Tool Company

EXCLUSIVE

DEVELOPMENT of the process of acidizing oil wells,[1] more than any other single item, has done much toward recovering the maximum amount of oil from many reservoirs. But in certain types of wells[2-3] it was early recognized that the process of acidizing needed refinement. For instance, in those wells where the lithology changed in the open hole section, there was no real control over where the acid would go, using normal treating technique. Usually this would be the zone of greatest permeability. The problem, then, was quite apparent; the acid had to be confined to a specific zone during treatment of the well.

There have been several developments, both from the angle of technique and special tools, pointing towards the art of selective acid treating. But it was not until development of the Electric Pilot[4] that the operator at the surface could be certain of the exact position of the acid in the well at all times during the treatment. Through the use of this instrument it also is possible to determine the relative permeabilities, in place, of the different sections of exposed formation. However, as this particular application of the tool has been the subject of separate study,[5] this paper will discuss the use of the Electric Pilot in selective acidizing.

▸ **Methods used in selective work.** Several methods have been used in the past and are now being employed in an effort to acidize selectively in wells. Briefly, some of them are as follows:

1. The use of an additional pump, or pumps, to supply oil to the annulus or to the tubing, depending upon whether it is desired to hold acid to the lower or upper sections of the pay zone. With this method by itself, it is not possible to know definitely at what point the acid is entering the formation.

2. Application of acid to the face of the formation by jetting. This method applies primarily to open hole completions and is quite effective in removing cement sheaths or other surface obstructions. The method definitely permits control of the point at which the acid impinges upon the surface of the formation but, thereafter, control is lost and the acid will enter the formation through the most permeable zones.

3. The use of packers. Under some circumstances this method proves quite effective. However, its application is limited by formation and hole conditions, and the hazard of mechanical complications is always present. Also, the pressures that may be used to force acid into the pay zones may cause circulation of the packer and a consequent loss of acid.

4. The spotting of temporary plugging agents such as mud or Jelly Seal, then attempting to acidize the unplugged sections. Again, with this method by itself, it is not possible to know definitely that the desired section of the formation is acidized.

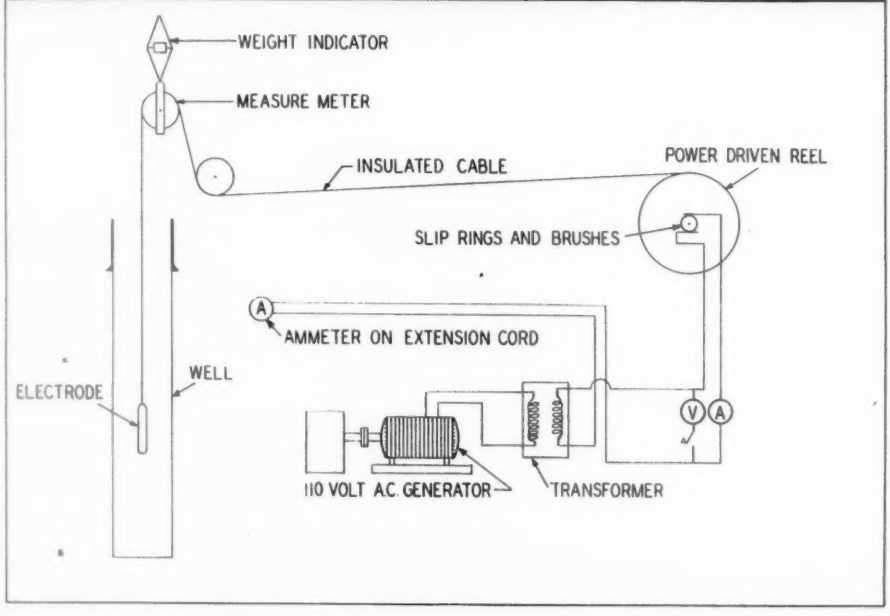
5. The Electric Pilot. This will be considered somewhat in detail in the following discussions.

▸ **The Electric Pilot.** The Electric Pilot is an apparatus through which the interface between two liquids with dissimilar electrical conductivities can be accurately located in a well. It has been described in detail in previous literature so a brief outline will suffice here. Primarily, the Electric Pilot unit is made up of a source of electricity, a circuit consisting of an insulated single conductor cable that can be run into a well, and a special electrode assembly that can be run into the well on the cable. A schematic diagram of the unit is shown in Fig. 1. The cable is carried on a power driven reel, which together with the generator and all other auxiliary equipment is truck mounted as a compact unit. Slip rings and brushes permit completing the electrical circuit from the cable mounted on the reel to the generator and recording instruments. Detail of the electrode, as used in selective acid treating, is shown in Fig. 2.

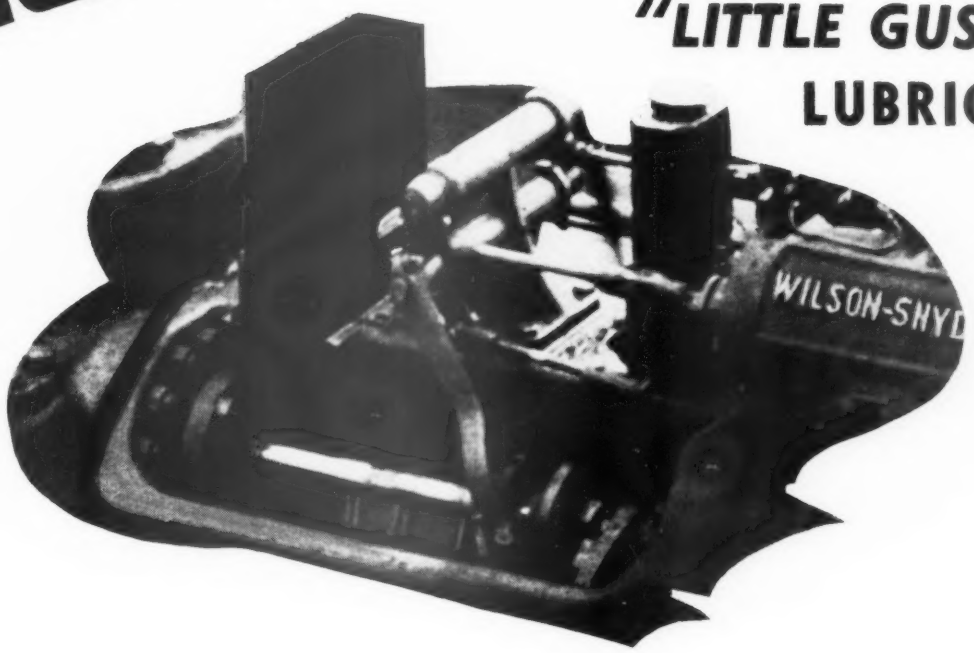
The tubing is run into the well with an ordinary seating nipple on the lower end. This seating nipple is run to a pre-determined point in the open hole or perforated section, either above or below which it is desired to force the acid into the formation.

FIG. 1.

DIAGRAM OF ELECTRIC PILOT EQUIPMENT



100% ROD LUBRICATION with the WILSON "LITTLE GUSHER" LUBRICATOR



NO DRY STROKES . . . NO WASTED OIL

More and more Drilling Contractors and Superintendents throughout the Drilling Industry are finding that Oil lubricated slush Pump Rods last longer—and that The Wilson "Little Gusher" Lubricator is the ONE foolproof way of getting the oil to the rods.

With the "Little Gusher" there are no "Dry Strokes." Oil flows on to the rods by gravity with the start of the pump. There is no "splashing" with the resultant waste of oil.

Vacuum operated, the Wilson "Little Gusher" Lubricator gives automatic, continuous oil lubrication to the rods. The only moving part in the Lubricator is a float operated Toggle Valve—and as it is submerged in oil there is very little wear.

Contact your nearest Wilson Supply Company Store—or write the Houston office for complete information on this worthwhile product.

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The electrode, as shown in Fig. 2, is run in on the cable and landed in this seating nipple. When this electrode is immersed in a non-conducting fluid such as oil, the electrical circuit is not completed but when acid is in contact with it the circuit is completed and the flow of current is indicated by the instruments on the surface. Through the use of varying resistance units located at definite vertical intervals in the electrode assembly, the vertical point at which the electrical circuit is completed is indicated within a limit of one foot by the amount of current moving through the circuit. This information is registered on the surface instruments and indicates either the exact location of the oil-acid interface or whether this interface is above or below the electrode. With such information available at the surface, it is possible to keep the fluid interface at the desired point or vertical position in the producing formation by varying the rates at which fluid is pumped into the tubing or annulus, as may be required. Thus it is definitely known that the acid is confined to that section of the formation it is desired to acidize.

In addition to the function of the Electric Pilot just mentioned whereby fluid injection control is maintained thus permitting acidization of the desired sections of the formations, it should be brought out here that it also is used for determining the relative permeability of the pay section.[6] This is done by following an oil-water interface as it is pumped down the well bore under controlled conditions. As fluid enters the permeable zones of the formation, the rate of descent of the interface slows down in proportion to the amount of fluid entering the formation. Finally, under constant pumping conditions, the interface will either be pumped to the bottom of the hole, indicating permeability there, or the interface will stop at some point in the formation up the hole, which in turn indicates that all the relative permeability under conditions then obtaining is in the section of the hole above that point. In some instances, where it is not practical to introduce two fluids such as oil and water for forming an interface, it is possible by means of a special type of flow meter to survey the injection and producing characteristics of the formation.[7-8] This impeller type flow meter or "Spinner," as it is called, is run with the regular Electric Pilot unit and the pertinent data are recorded by suitable surface instruments.

Reservoir and well conditions. The following outline briefly points out some of the reservoir and well

DIAGRAM OF ELECTRODE

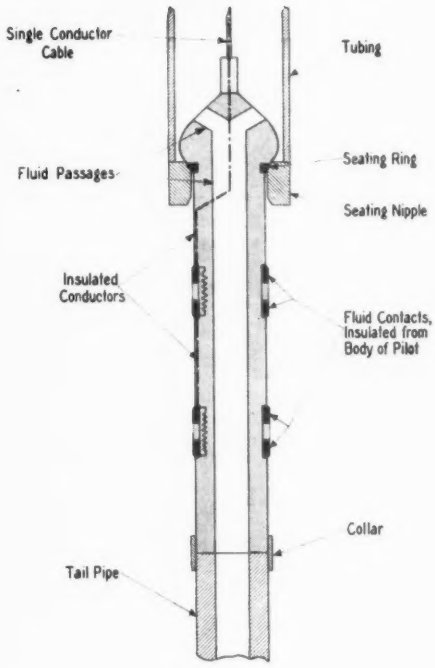


FIG. 2

conditions under which selective acidizing should be considered.

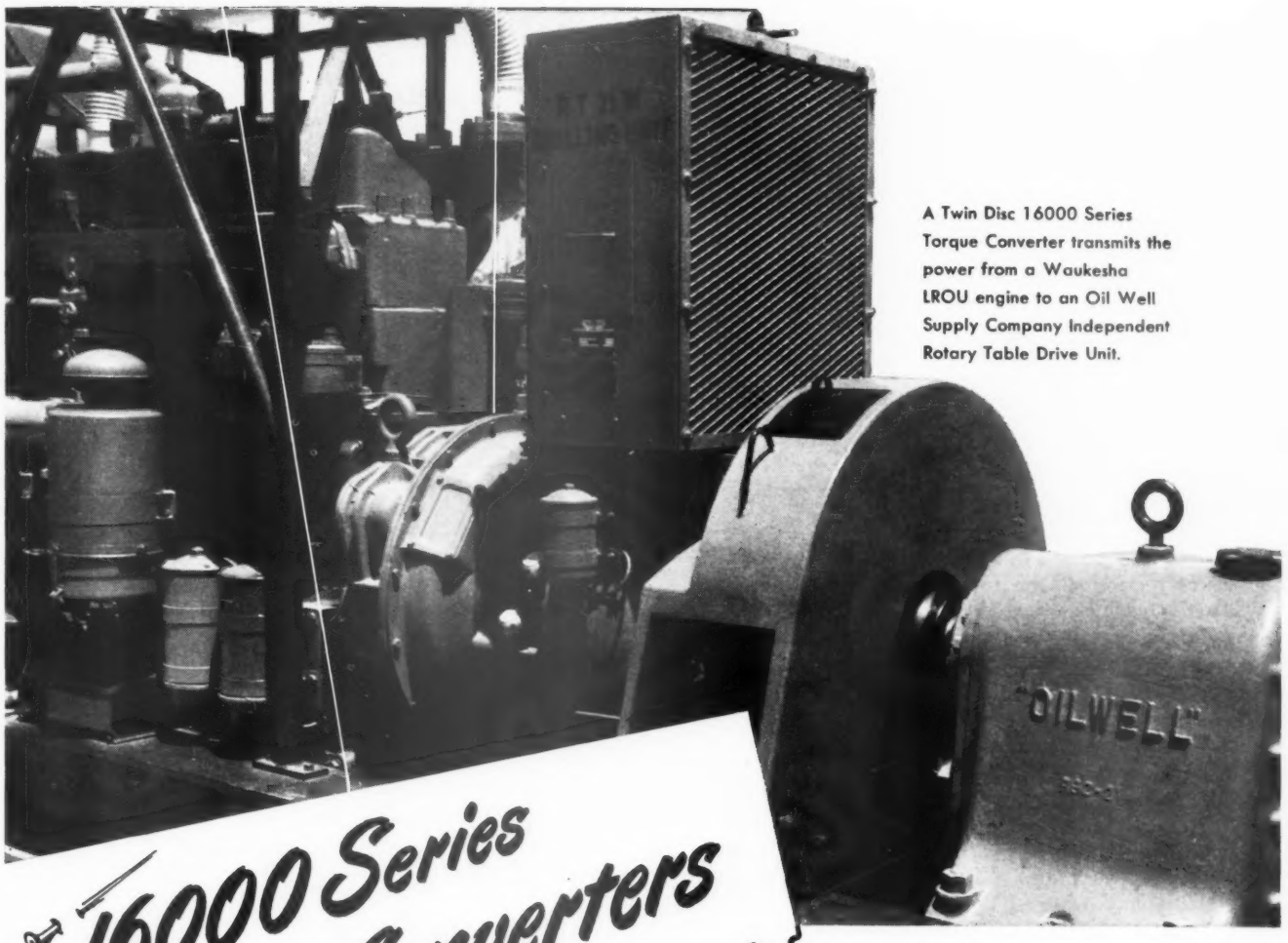
1. New wells in which a change in lithology is present in the open hole or pay section. Such changes may involve sand, lime, dolomite, primary or secondary anhydrite.
2. New wells in which saturated zones of varying permeability are present.
3. Wells showing excessive gas-oil ratios, but with the possibility of additional available oil present in tighter saturated sections.
4. Wells in which it is desirable to make additional gas available.
5. Wells with intermediate water zones.
6. Wells deepened to new pay zones.
7. Old wells with depleted zones but with oil remaining to be recovered from the tighter sections.
8. Wells in which it is desirable to hold acid away from plug-back or other repair work, including Securaloy liners, plastic or cement squeeze and re-drill jobs.
9. Wells in which conditions are such that it is important to keep acid away from the casing seat.
10. Injection wells in which it is desired to have uniform distribution of the gas or water being returned to the formation, or in which it is desirable to alter existing injection characteristics.

In general, selective acidizing is applicable to wells producing through perforations in casing set through the pay section, together with those wells producing from open hole with the casing set above or on top of the producing zone. In some instances, however, there may be conditions present that will cause complications in wells completed in either of these ways. Channeling behind the pipe and vertical fissures or fractures in the producing formation are two such conditions that might be mentioned. Oftentimes control can still be effected in some instances under these conditions, however, through the proper application of materials that tend to bridge and build up an effective filter cake, thus blocking the movement of fluid into the channels or fractures. In other instances, the conditions mentioned may be too drastic to permit effective control through the use of these materials.

Preliminary planning. The general reservoir and well conditions under which it may be quite important to give consideration to selective acidizing work already have been outlined. In this connection, it might be well to mention a few items that, if given thought and study in specific cases, may go a long way toward assuring satisfactory results from the selective type treatment. All available bottom-hole data should be plotted and correlated. Permeability surveys have been found to be of primary importance for comparison and correlation with geological information and, under certain conditions, temperature surveys are quite valuable. Other items for determination and consideration are the possibility of emulsion troubles being encountered, gravity of the oil to be used and solubility of the formations to be acidized. After considering all the available information, including past experience with conventional and selective acid work in the area, where available, the proper procedure for the individual well can be derived.

Conditions may be such in certain wells that stage treating is desirable. In such cases, the tighter, less permeable section or sections should be acidized first. Experience gained on these treatments indicates that better results usually are obtained when the well is cleaned up by swabbing or flowing between stages.

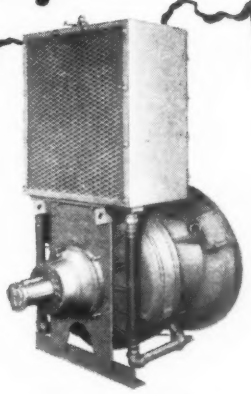
Sometimes it is necessary to use a temporary plug back to shut off the lower part of an open hole and then use oil and the standard selective electrode to keep acid out of an upper section while injecting acid into a middle zone. Often, too, it may be necessary to use a surface plugging



A Twin Disc 16000 Series Torque Converter transmits the power from a Waukesha LROU engine to an Oil Well Supply Company Independent Rotary Table Drive Unit.

16000 Series Torque Converters

. . . for the 250—600 hp Range

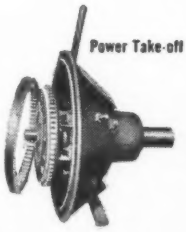


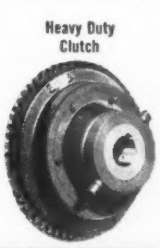
Twin Disc 16000 Series Torque Converter

Deep-hole drilling requires more power, and better power transmission equipment. That's why Twin Disc designed its 16000 Series Hydraulic Torque Converter—to meet the requirements of rigs using one or more engines in the 250 to 600 hp class.

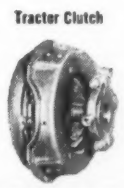
Like all Twin Disc Hydraulic Torque Converters, Series 16000 automatically and instantaneously selects the proper torque ratio for the load and the engine power . . . permits uninterrupted acceleration to a maximum speed and an efficient handling of the load . . . cushions all shock loads and torsional vibrations . . . leaves no gear shifting or guesswork to the operator.

The complete line of Twin Disc Hydraulic Torque Converters (Lysholm-Smith type) include three series; 10000, 11500, and 16000 . . . applicable to engines with horsepower ratings of from 30 to 600 hp. For complete information, write the Hydraulic Division for Bulletin 135-C or Bulletin D-430 which refers specifically to the 16000 Series Converters. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Ill.)





TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES



SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

agent mixed with a small volume of the oil being pumped into a loose section in order to build up sufficient working pressure to inject the acid into the zone for which it is intended.

Equipment used; procedure. It is necessary to have at least two pump trucks and the Electric Pilot Unit in order to handle and complete successfully this type of selective acid treatment. A sufficient supply of oil, for both flush to displace the acid into the formation and the volume necessary to control the acid-oil interface, must be readily available. The tubing with the seating nipple on the lower end must be run to the desired depth.

There are three general sets of conditions encountered in selective acidizing as follows:

1. Where it is desired to acidize the lower section of the formation. This is usually referred to as a standard selective treatment.
2. Where it is desired to acidize the upper section of the formation. This is usually designated as a reverse selective treatment.
3. Where it is desired to acidize an intermediate section. This is really a variation of Number 1, inasmuch as it is necessary here to plug off the bottom zone temporarily and proceed thereafter as in a standard selective treatment.

In a standard selective treatment, the electrode is lowered into the tubing on the insulated cable and positioned in the seating nipple. The length of the electrode extending below the nipple is approximately four feet. The acid then is pumped down the tubing. At a point about four inches above the seating nipple, the acid enters the fluid passages in the electrode, passes through the hollow center and is delivered to any depth desired by means of a length of tail pipe. Under some formation and well conditions, the use of this tail pipe is of great importance. By means of it, acid is placed in direct contact with and distributed across the full vertical section of the formation to be treated. As the acid rises in the well bore around the outer surface of the electrode, its position is indicated by readings on the instruments at the surface. By increasing or decreasing the rate at which oil is pumped down the annular space through use of the second pumping unit, while acid is continually being pumped down the tubing, the interface can be controlled and held to any vertical point on the electrode. Thus the acid is forced out into the formation below this point, or from the lower section of the well bore.

DATA FROM REPRESENTATIVE WELLS SELECTIVELY ACIDIZED

Pool, County State	Pay formation	Oil production (bbl per day)		Acid gal	Remarks
		Before	After		
Slaughter—Hockley County, West Texas	San Andres	72	840	8,000	New well. This stage of acid controlled below very permeable gas and oil zone. GOR reduced from 4350 to 605-1 by increasing oil production from bottom of hole.
Slaughter—Hockley County, West Texas	San Andres	48	648	7,000	New well. First stage of 4000 gal controlled above intermediate water zone. Second stage of 3000 gal controlled below. Well produces pipe line oil.
Wasson—Yoakum County, West Texas	San Andres	60	744	5,000	Old well. Original open hole squeezed with 200 sacks of cement, then redrilled making 70 ft of new hole. This stage of acid controlled to new hole. GOR reduced from 16,000 to 1500-1.
Goldsmith—Ector County, West Texas	San Andres	11	200	2,500	Old well. Securaloy liner set through gas zone before this stage of acid. Acid controlled below the liner. GOR reduced from 16,000 to 1500-1.
Eunice—Lea County, New Mexico	Yeso	278	312	1,500	New well. Acid controlled below plastic squeeze around casing seat and upper 12 ft of hole. GOR reduced from 8100 to 856-1.
E. Cowden—Andrews County, West Texas	Grayburg	19	45	3,000	Oil well. Conventional treatment failed to produce results. This stage of acid controlled to the least permeable section of pay zone, after survey.
Howard-Glasscock, Howard County, West Texas	San Andres, San Angelo and and Clearfork	25	165	10,000	New well. Inside location drilled several years after offset wells completed. Part of acid controlled to less permeable saturated zone below sandy section, after survey.
McCamey—Upton County, West Texas	San Andres	Trace	18 oil 25 water	2,000	Old well. Previous to workover produced 100% water. Plugged back with plastic. Survey indicated either casing seat leak or permeable zone above possible pay. Acid controlled between plugged back depth and upper open section.
McElroy—Crane County, West Texas	Grayburg	6	30	5,000	New well. Survey indicated 92% of relative permeability in open hole above two pay streaks. Acid controlled with oil and temporary plugging material to oil bearing zones.
Throckmorton—Throckmorton County, North Texas	Caddo Lime	Show	50	500	This well made approx. 5,000,000 cu ft gas per day, with show of oil. After treatment gas ratio lowered. 50 bbl oil per day.
K.M.A.—Wichita County, North Texas	Ellenburger	30	39 BP hr	4,000	12 bbl water per day before treatment. No increase of water at time of test.
K.M.A.—Wichita County, North Texas	Ellenburger	12	50 BP hr	3,000	Gas oil ratio changed from approx. 20,000 to approx. 500-1.
K.M.A.—Wichita County, North Texas	Ellenburger	10	50	5,000	No apparent increase in water following treatment.
Panhandle—Hutchinson County, Texas	Panhandle Dolomite	(New well) (No test)	100	5,000	Pilot used to hold acid below a liner, blanking off an upper gas zone.
Wildcat—Ellis County, Kansas	Arbuckle	32 BO/D	48 BW/D 432 BO/D	1,000	34 bbl oil to control interface.
Merten—Barton County, Kansas	Arbuckle	36 BO/D	123 BO/D	1,000	30 bbl oil to control interface. Reverse job.
Hall-Gurney—Russell County, Kansas	Kansas City	10 BO/D	21 BW/D 189 BO/D	1,000	254 bbl oil to control interface.
Hall-Gurney—Russell County, Kansas	Kansas City	54 BO/D	216 BO/D	3,000	99 bbl oil to control interface.
Doran—Rice County, Kansas	Arbuckle	120	524	750	Well recompleted through conglomerate, liner perforated at lower pay. 9 bbl oil to control interface.
Rutherford—Pawnee County, Kansas	Arbuckle	(New well) (no test)	192	2,000	Acidized upper break in Arbuckle holding acid out of lower pay due to danger of water.
Turley—Osage County, Oklahoma	Arbuckle	6	140	1,500	Pipe not cemented. Producing under a formation packer, with water section above.
Turley—Osage County, Oklahoma	Arbuckle	8	120	1,000	Pipe not cemented. Producing under a formation packer, with water section above.
Midway—Lafayette County, Arkansas	Smackover Lime	(Gross P.O.) (079)) (Oil P.I.) (062—) (Water 12%)	(Gross P..I) (143—) (Oil P.I.) (102—) (Water 28%)	1,000	Hold down P.I. indicates water in bottom.
Midway—Lafayette County, Arkansas	Smackover Lime	(Gross P.I.) (143—) (Oil P.I.) (102—) (Water 28%)	(Gross P.I.) (192—) (Oil P.I.) (148—) (Water 20%)	1,000	Increased oil on holdup job.
Carthage—Panola County, Texas	Pettit Lime	20,000 cu ft gas	10,000,000 cu ft gas	5,000	Hold down until two zones had equal permeability.
Haynesville—Claiborne Parish, Louisiana	Pettit Lime	30 oil 21,000/1 G/O	125 oil 4,200/1 G/O	2,000	Plugged back. Held acid off plastic plug.
Haynesville—Claiborne Parish, Louisiana	Pettit Lime	19,000/1 G/O	Allowable at 1950/1 G/O	2,000	Plugged back. Held acid off plastic plug.

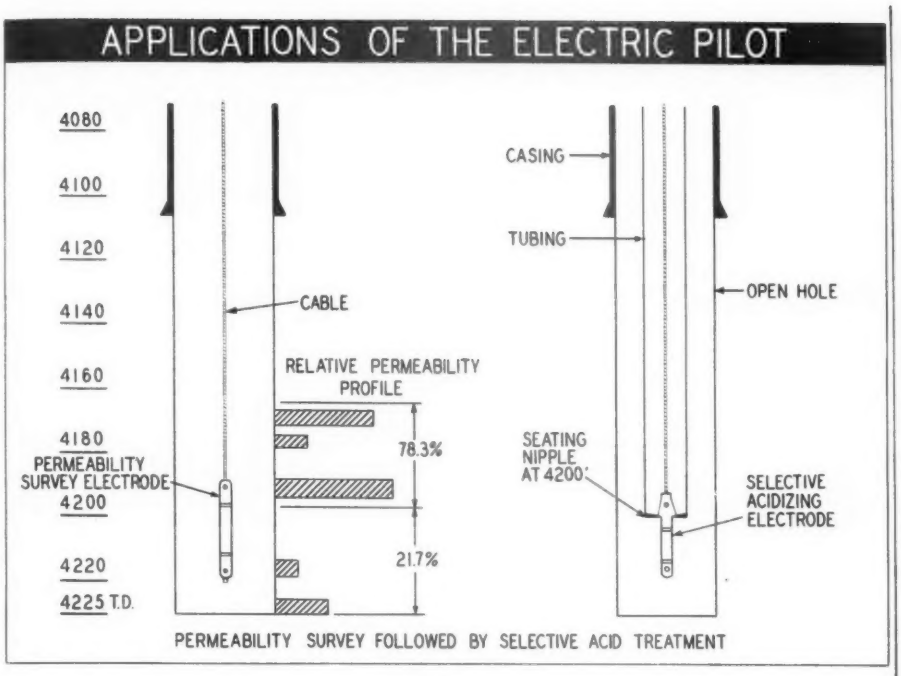
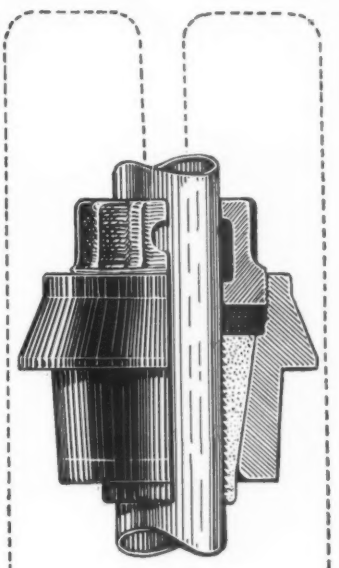


FIG. 3.

In the reverse selective treatment, where the upper section of the exposed formation is to be acidized, the same type of electrode is used to control the interface, the only difference being that the resistance units are arranged in reverse order so that encroachment of the acid from above on the electrode will be shown, rather than from below as is the case in the standard selective treatment. In this type of work, the acid is to be held above some pre-determined point, with oil below. The acid either is pumped down the annular space between the tubing and casing or is pumped down the tubing and positioned up in the annulus above that section of the formation to be treated. In case the latter procedure is followed, sufficient velocity must be maintained by the pump to prevent the acid from settling through the oil at and below the lower end of the tubing and thus coming in contact with the lower portion of the formation that is not to be treated. If this procedure is not practical, the lower section must be protected by some material that will prevent settling of the acid through it. After the oil-acid interface has been brought to the desired point on the electrode, the selective treatment is made by pumping the required volume of oil flush down the annulus to force the acid into the formation, at the same time maintaining whatever oil pumping rate is necessary on the tubing to control the interface and keep it at the desired point on the electrode assembly. As mentioned previously, the readings on the surface instruments reflect either the exact position of the interface with reference to the electrode or whether the electrode is completely immersed in oil or acid, with the interface, consequently, either above or below it.

If proper control is to be maintained in selective acidizing, it is better that the hole support a full column of oil and be full of oil when the work is started. Under circumtances, however, when the hole will not support a column of fluid to the surface, the balanced column technique has been employed to carry out successful selective acid treatments. With the acid and oil introduced into the well under favorable conditions, emulsion problems are minimized and a clearcut acid-oil interface usually is established which reflects distinct readings on the surface instruments. This, in turn, permits exact control of the acid into the desired section of the formation, unless physical conditions are such within the well bore that sufficient oil cannot be supplied to control the interface. This situation could be due either to the extreme tightness of the section to be treated or to the extreme looseness of the section from which it is desired to keep the acid. If these conditions should obtain, the fact is usually known ahead of time but, in any event, as mentioned before, surface plugging materials or fillers can be mixed with a small volume of the control oil. In this manner, sufficient pressure ordinarily can be built up to permit the desired acidizing procedure to be carried out.

In the infrequent instances where



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the control procedure breaks down and it is not possible to hold the interface at the desired level, certain information of value is obtained from the use of the Electric Pilot in the selective treatment, inasmuch as the fact is definitely established that the zone of low permeability was not acidized. Then if the response of the well to the treatment was not satisfactory and the saturation or other data would seem to justify further work, steps can be taken through the use of proper surface plugging materials, fillers, or otherwise to carry out the selective work as planned.

▸ **General.** In a number of areas where extremely tight sections with low permeability are present, it has been determined that surface tension reducing agents contribute materially to the efficiency of acidizing. They have a definite place, under some conditions, in slective acidizing work. Through the use of these agents, the surface tension of both the fresh acid and the spent acid water solution is reduced as much as 50 per cent or more.[9] It is possible to reduce surface tensions of these liquids from the 75 to 80 dynes per centimeter range to that of 28 to 32 dynes per centimeter. Such changes in this important physical characteristic result in (1) better penetration of the formation to be acidized, at lower pressures, and (2) better and more complete removal from the formation of the spent solution. In selective work the first of these results contributes not only to more effective acidizing but also reduces the amount of control oil needed during the treatment. The second result means that Jamin action within the producing zone is reduced and the formation of undesirable emulsions is minimized both within the producing zone and in the fluid produced. Laboratory work has shown that the resistance to flow of spent acid solution through core specimens, under certain conditions, has been reduced as much as 87 per cent through the use of proper surface tension reducing agents.

▸ **Conclusions.** It has been possible in a number of pools in several different areas to work out definite procedures and programs of selective acidization through which important reserves have been made available that otherwise, due to the marginal nature of the operation as a whole. would not have been recovered. This has been brought about largely by determination and analysis of reservoir conditions in which permeability surveys have played an important part. As has been aptly pointed out by others in the past, we are a long distance from our work when dealing with a producing horizon several thousand feet below the surface of the ground. The Electric Pilot is a very definite and effective aid when it comes to feeling our way around under such conditions. This instrument not only sheds light on the existing physical reservoir conditions in new work or in recompletions but. thereafter, quite often provides the means for properly guilding and controlling the required procedures.

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Bureau of Mines Analyses of Subsurface Oil Samples From North Lindsay Field, McClain County, Oklahoma

ALTON B. COOK, G. B. SPENCER, F. P. BOBROWSKI, and E. J. DEWEES*

● **Introduction.** A highly volatile type oil was found in Oklahoma with the discovery in 1945 of the North Lindsay field in McClain County. At the time of discovery, the Cities Service Oil Company Lawson A well No. 1 was the deepest commercial producer in Oklahoma (approximately 11,000 ft), the location being in the southeastern part of the Anadarko Basin. Because of the unusual physical properties of the reservoir oil and possible future discoveries of similar oils in deep-seated reservoirs in this area of the Anadarko Basin, subsurface samples were obtained, and well-test data were assembled and are presented in the following report.

The oil produced from the Bromide formation in the North Lindsay area is different from most oils found in other oil-producing areas in the State for the following reasons:

(1). The gravity of the stock-tank oil is high, being approximately 46° API;

(2). The solution gas-oil ratio of the initial reservoir oil was higher than that of any other known oil in Oklahoma reservoirs, being approximately 2500 cu ft per bbl by the flash gas-liberation method:

(3). More than 2 bbl of the initial reservoir oil must be produced to yield 1 bbl of oil in the stock tank:

(4). The gas liberated from the oil in the reservoir at approximately initial reservoir pressure had a specific gravity of approximately 0.83, air = 1.0, and the mole per cent of "butane plus" in the gas was 8.6;

(5). The density of the initial reservoir oil was 0.49 gram per cubic centimeter or 30.6 lb per cu ft, and

(6). The viscosity of the initial reservoir oil was 0.16 centipoise, which is less than that of water (the viscosity of water at reservoir temperature, 189 F. is approximately 0.33 centipoise).

This report, in addition to being a discussion of the principal physical characteristics of the reservoir oil in the North Lindsay field, includes a structure map of part of the Bromide sandstone reservoir and data on the following:

(1). Summary of field and laboratory data of four Cities Service Oil Company wells (Odom No. 1, Lawson B No. 1[1], Robinson No. 1[1], and Lawson D No. 1[1], that were tested and sampled:

(2). Pressure-volume-temperature relationships of a subsurface oil sample (Lawson B-1):

(3). Differential and flash gas-liberation data (Lawson B-1):

(4). Well test data (changes in gas-oil ratios for changes in producing conditions for the Lawson B-1 and Robinson 1 wells);

(5). Effect of separator pressure on properties of stock-tank oil (flash gas-liberation data on subsurface oil sample from Odom 1);

(6). Pressure viscosities of subsurface oil sample (Lawson B-1);

(7). Low-temperature fractional analyses of (a) subsurface oil sample, (b) separator sample, (c) separator gas sample, and (d) free gas in reservoir (items a, b, and c are from Lawson B-1, item d is from Robinson-1);

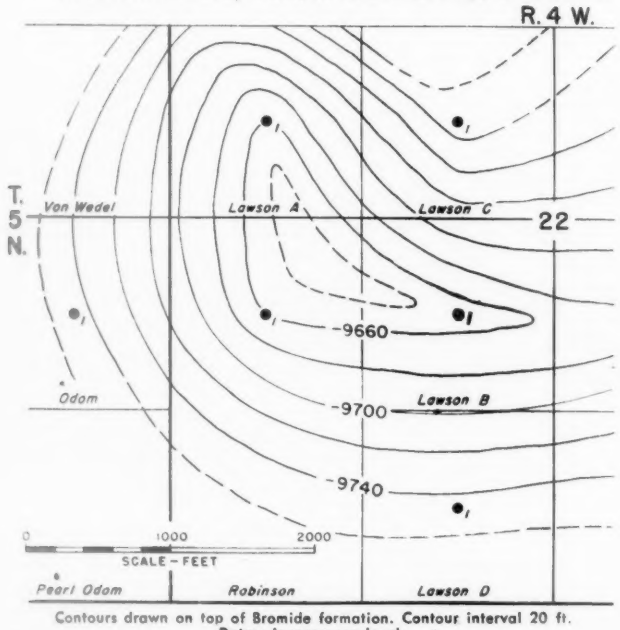
(8). Hempel analyses of stock-tank oil (Lawson B-1).

● **North Lindsay field reservoir.** The North Lindsay structure is located in the

*Petroleum engineers, Bureau of Mines, Bartlesville, Oklahoma.

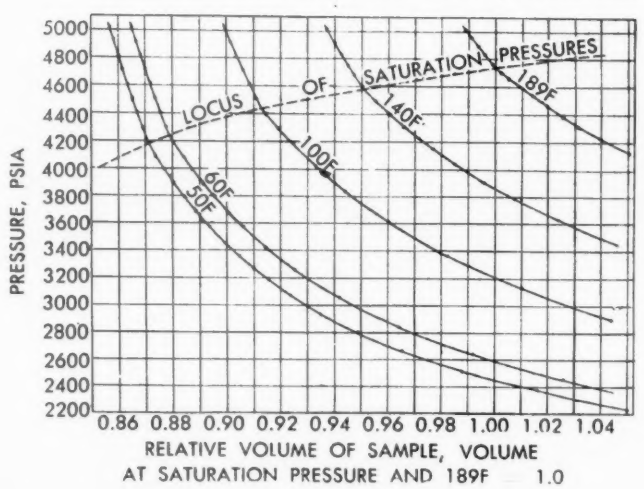
[1]Cities Service Oil Company, operator. Jointly owned by Cities Service Oil Company, Mid-Continent Petroleum Corporation, and Phillips Petroleum Company.

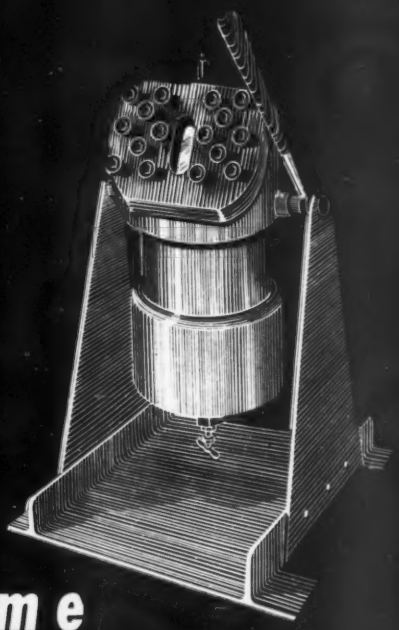
FIG. 1. Subsurface structure map showing part of the North Lindsay field, McClain County, Oklahoma.



Contours drawn on top of Bromide formation. Contour interval 20 ft. Datum is mean sea level.

FIG. 2. Pressure-volume-temperature relationships of subsurface oil sample from Cities Service Lawson B-1, North Lindsay field, McClain County, Oklahoma.





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Flash Liberation: to determine the optimum separator pressure which, in turn, influences the gravity and volume of stock tank oil.

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northwestern part of the Arbuckle Mountain uplift and in the southeastern part of the Anadarko Basin. Although oil was found in both the Hunton limestone and the Bromide sandstone, this report is confined to a discussion of the characteristics of the oil from the Bromide sandstone reservoir and the producing performance of wells bottomed in that formation. The average depth to the midpoint of the Bromide standstone reservoir is approximately 11,000 ft; the average thickness of the productive sand section is approximately 450 ft. A structure map of the Bromide sandstone reservoir, in the part of the field containing the wells that were tested and sampled, is shown in Fig. 1. Most of the reservoir rock is extremely hard and of low porosity and permeability. There are several streaks of high porosity and permeability, however, which are sufficient in some parts of the reservoir for the wells to have high oil-potentials. These bodies of high porosity probably are lenticular because subsurface pressure data do not show measurable communication between wells.

Considerable time elapsed between completion of the discovery well (Lawson A-1) and other wells located in the immediate vicinity. As the bottom-hole pressure declined at an appreciable rate in the area about Lawson A-1, the first reservoir pressures obtained in offset wells were expected to reflect the decline of pressure about the discovery well, but the initial pressures in some wells were found to be even higher than in the discovery well. Comparisons of the bottom-hole pressures of the Lawson B-1 and Robinson 1 wells at the time of their completion with the bottom-hole pressures in the Lawson A-1 are shown below:

Well	Completion date	Location from Lawson A-1	Pressure at −9900 ft		
			Aug. 8, 1945	Oct. 20, 1946	Jan. 8, 1947
Lawson A-1	Aug. 8, 1945		4750	2810	2421
Lawson B-1	Oct. 20, 1946	S. E. offset	..	4925	4760
Robinson 1	Jan. 8, 1947	South offset	..	..	4950

TABLE 1. Summary of field and laboratory data on subsurface oil samples from the North Lindsay field, McClain County, Oklahoma.

Lease operator Lease and well no.	Cities Service Oil Company Odom well no. 1	Cities Service Oil Company Lawson B well no. 1	Cities Service Oil Company Robinson well no. 1	Cities Service Oil Company Lawson D well no. 1
Field data				
Name of producing formation	Bromide sandstone	Bromide sandstone	Bromide sandstone	Bromide sandstone
Date of well completion	7-29-46	10-20-46	1-8-47	10-19-47
Elevation of derrick floor above sea level, feet	1,061	1,099	1,064	1,083
Total depth of well, feet	11,250	11,200	11,158	11,120
Length of casing (oil string 7 in. OD), feet	10,857	10,753	10,721	10,832
Length of tubing (2½ in. EUE), feet	11,019	10,751	10,704	10,814
Subsurface-oil samples obtained at a depth of, feet	10,800	10,699	10,600	10,683
Flowing pressure at sampling depth, psia	13,833	[2]4,765	[3]4,198	[2]4,324
Flowing pressure at mid-point of producing formation (datum 9900 ft below sea level), psia	3,875	4,832	4,264	4,399
Static pressure at sampling depth, psia	4,436	4,811	4,248	4,426
Static pressure at mid-point of producing formation (datum 9900 ft below sea level), psia	4,478	4,879	4,276	4,504
Estimated average initial reservoir pressure, psia	4,925	4,925	4,925	4,925
Reservoir temperature at 9900 ft below sea level, F	189	189	189	189
Oil producing rate, bbl/day	60	88.4	244.8	95.7
Separator pressure, psia	45	61	514 and 67	95.7
Separator temperature, F	83	60	60	49
Producing gas:oil ratio[4] (separator gas:stock-tank oil ratio), cu ft/bbl	2,250	2,588	[5]3,640	1,866
Gravity of stock-tank oil at 60 F, degrees API	44.4	47.1	50.8	45.5
Specific gravity of gas from gas-oil separator, air=1.0	0.796	0.741	0.680	0.742
Date of obtaining subsurface oil samples	8-23-46	11-6-46	4-28-47	10-31-47
Laboratory data				
Method of gas liberation[6]	Differential / Flash	Differential / Flash	Differential / Flash	Differential / Flash
Saturation pressure of subsurface-oil sample at 189 F (reservoir temperature), psia	4,335 / 4,335	4,730 / 4,730	4,178 / 4,178	4,345 / 4,345
Volume of gas in solution from atmospheric pressure to saturation pressure, cu ft per bbl of residual oil[4]	2,493 / 2,083	3,694 / 2,970	1,898 / 1.655	2,151 / 1,878
Volume of gas in solution from atmospheric pressure to separator pressure, cu ft per bbl of residual oil[4]	34	23	27	25
Volume of gas in solution from separator conditions[7] of pressure and temperature to saturation pressure, cu ft per bbl of residual oil[4 8]	2,049	2,947	1,028	1,853
Estimated volume of gas in solution from atmospheric pressure to estimated initial reservoir pressure (4925 psia) if the reservoir oil had been initially saturated with gas, cu ft per bbl of residual oil[4]	5,200 / 4,100	5,400 / 4,200	2,800 / 2,450	2,700 / 2,400
Relative oil volume at saturation pressure, residual oil volume at 60 F=1.0	2.403 / [2]2.163	3.073 / [2]2.647	2.047 / [3]1.912	2.184 / [2]2.007
Relative oil volume at separator pressure, residual oil volume at 60 F=1.0	1.034	1.028	1.018	1.015
Density of oil at saturation pressure and reservoir temperature, gm per ml	0.532	0.481	0.560	0.554
Viscosity of oil at saturation pressure and reservoir temperature, centipoise	0.18	0.16	0.185	..
Gravity of residual oil at 60 F, deg API	42.5 / 45.0	43.2 / 46.9	42.6 / 44.9	41.6 / 44.1

[1]Sample obtained after the well had been shut-in for two days.
[2]Sample obtained while well was flowing.
[3]Sample obtained after well had been shut-in 1 hr.
[4]All volumes of gas were corrected to 14.4 psia and 60 F.
[5]Combined gas from both high and low pressure separators.
[6]Differential- and flash-gas liberation defined in Bureau of Mines Tech. Paper 629, 1941, p. 5.
[7]To facilitate comparisons, separator conditions of 64.4 psia and 60 F were simulated in each of these flash-gas liberation experiments.
[8]Flash gas-liberation data should be used when comparing solution and production gas-oil ratios.
[9]Volume of oil in reservoir equivalent to one volume of stock-tank oil.

Another indication that the reservoir is lenticular is that one well, the Robinson 1, produced "free gas" (gas produced with residual oil in excess of gas dissolved in the reservoir oil) along with the oil. The gas-oil ratio of this well was considerably higher than for any other well in the field, although two wells in the immediate area of the Robinson 1 were structurally as high or higher (see Fig. 1).

● **Initial saturation pressure of reservoir oil.** Four wells were tested and sampled in an attempt to obtain complete understanding of the physical properties of the North Lindsay field Bromide reservoir oil (see Table 1). The saturation pressure of the reservoir oil, however, was not determined because it was not possible—for reasons hereafter cited—to obtain representative samples of the oil at approximately the initial reservoir pressure. The "productivity index" of the first well tested and sampled (Odom 1) was so low that flow rates of only 60 bbl of oil per day reduced the bottom-hole pressure several hundred pounds per square inch. The Robinson 1 produced free gas from a gas-bearing lens along with the oil. The pressure in the Lawson D-1 declined at such a rapid rate that the static bottom-hole pressure was reduced, at least temporarily, approximately 500 psi while the well was being cleaned out and made ready for testing and sampling.

Although, at the time of sampling, the bottom-hole pressure in the Lawson B-1 had declined only a small amount, and its productivity index was high, the subsurface oil sample and well test data obtained did not lead to a definite conclusion concerning the saturation pressure of the reservoir oil. A study of the well test data and laboratory data on the subsurface oil samples led to the conclusion that both free gas and oil undersaturated with gas flowed simultaneously into the well-bore of the Lawson B-1 well. One indication that free gas entered the well-bore is that the production gas-oil ratios for three flow rates were not constant and showed the highest gas-oil ratio for the lowest flow rate. This change in gas-oil ratio with change in flow rate (Table 2, test 1) is similar to the change that occurred in the Robinson well. Table 2, test 4.

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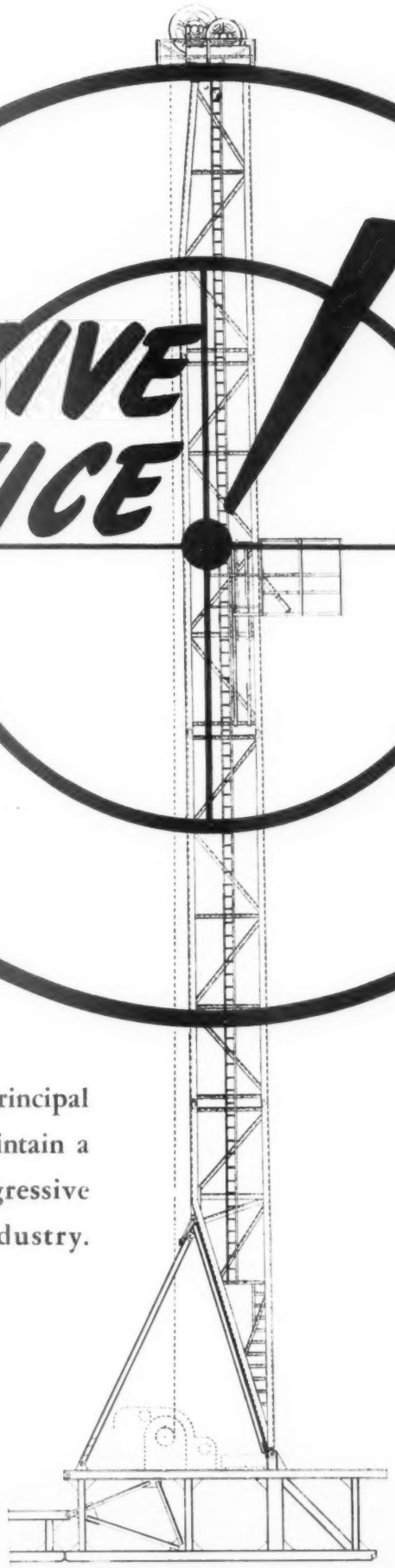

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TABLE 2. Flow test data, North Lindsay field, McClain County, Oklahoma.

Date	Choke size, in.	Subsurface pressure at −9900 ft, psi	Separator Press., psi	Separator Temp., F	Specific gravity separator gas, air=1.0	Oil production rate, bbl/day	Gas-oil ratio, cu ft/bbl (14.4 psia and 60 F)
			Lawson B Well No. 1				
			Test 1				
10-29-46 10-30-46	6/64	4,836	47	60	..	88.4	2,588
10-31-46 11- 1-46	8/64	4,835	47	60	0.741	173.7	2,434
11- 2-46 11- 3-46	10/64	4,804	47	60	..	267.2	2,320
			Test 2				
4-27-47 4-29-47	9/64	4,535	52	64	0.756	217.3	2,502
5- 1-47 5- 4-47	9/64	..	52	44	0.685	216.2	2,404
			Test 3				
11- 2-47 11- 4-47	11/64	4,240	63	60	0.756	303.9	2,850
11- 5-47 11- 6-47	11/64	..	[1]63 & 500	60	[2]0.697	318.1	[2]2,570
			Robinson Well No. 1				
			Test 4				
4-29-47 5- 1-47	8/64	4,286	[1]50 & 500	65	[2]0.699	71.7	[2]5,120
5- 2-47 5- 3-47	10/64	4,250	[1]53 & 500	60	[2]0.680	244.8	[2]3,640
5- 4-47 5- 5-47	14/64	4,172	[1]55 & 550	50	[2]0.680	503.9	[2]3,025

[1]Two gas-oil separators in series.
[2]Combined gas from both the high and low-pressure separators.

The saturation pressure of the subsurface oil samples was found to be 4730 psia (Table 3 and Fig. 2) whereas the static reservoir pressure was 4880 psia. The samples were obtained with the well flowing at an oil production rate of 88 bbl a day with a production gas-oil ratio of 2588 cu ft per bbl. The solution gas-oil ratio, obtained by conducting a flash-gas liberation on a subsurface oil sample to simulate producing conditions during the flow rate of 88 bbl a day, was found to be 2947 cu ft per bbl (see Table 4 and Fig. 4). Because this solution gas oil ratio was greater than the production gas-oil ratio, the ratio of free gas to oil trapped in the sampler must have been greater than existed in the flow string and the saturation pressure of the samples must have been greater than would have resulted from a representative composite sample of the flowing fluids (oil, solution gas, and free gas).

The gas-oil ratio of a representative composite sample of the flowing fluid in a well will equal the production gas-oil ratio. Reference to the "gas in solution" curve in Fig. 4 shows that the saturation pressure would be approximately 4625 psia when the solution gas-oil ratio (gas liberated between saturation and separator pressures) was 2588 cu ft per bbl or equal to the production gas-oil ratio when the flow rate was 88 bbl of oil a day. Although both free gas and undersaturated oil evidently entered the well bore simultaneously, the data are not sufficient for calculating the saturation pressure of the reservoir oil or the quantity of free gas that entered the well bore.

Because the saturation pressure of the reservoir oil was not determined and because of the lack of communication between wells and the complexity of the reservoir, no attempt is made to apply material-balance concepts to the North Lindsay field reservoir to predict future production gas-oil ratios or to estimate the portion of the oil and gas in the reservoir ultimately recoverable.

● **Effect of operating pressure and temperature in the gas-oil separator on properties of the stock-tank oil.** Five flash gas-liberation experiments were conducted on subsurface oil samples from the Odom 1 well in the North Lindsay field to determine the optimum operating pressure of the field separator and the advantage of using two field separators in place of one. The data, given in Table 5 and Fig. 5, show that when only one separator is used the optimum operating pressure is approximatly 225 psi. The data also show that when a high pressure separator, operating at a pressure of 772 psi, is connected in series with a separator operating at 50 psi the stock-tank oil recovery per unit volume of reservoir oil produced is increased approximately 3 per cent. (This increase can be calculated by comparing the relative oil volume data at saturation pressure shown in Table 5.) It seems likely that, as the production gas-oil ratio increases due to a reduction in reservoir pressure, the value of using two separators rather than one will become even more important because the produced fluid approaches the characteristics of that from a gas-condensate well. From the viewpoint of total liquid recovered, however, the use of two separators rather than one may be of little or no added value when all of the separator gas is processed in a natural gasoline plant.

Flow test data obtained on the Lawson B-1 well also show the effect of changing conditions of separator temperatures and pressure on the volume of gas liberated from the reservoir oil. Data obtained from April 27 to May 4, 1947 (Table 2, test 2) show the effect of changing sep-

TABLE 3. Pressure-volume-temperature relationships for a subsurface oil sample from Cities Service Oil Company Lawson B well No. 1, North Lindsay field, McClain County, Oklahoma.

Pressure, psia	Relative volume[1] of sample[3]	Pressure, psia	Relative volume[1] of sample	Pressure, psia	Relative volume[1] of sample	Pressure, psia	Relative volume[1] of sample	Pressure, psia	Relative volume[1] of sample
50 F		60 F		100 F		140 F		189 F	
5,017	0.8568	5,017	0.8649	5,017	0.8993	5,017	0.9371	5,006	0.9888
4,930	0.8502	4,914	0.8665	4,919	0.9014	4,914	0.9401	4,945	0.9912
4,811	0.8601	4,816	0.8682	4,814	0.9034	4,832	0.9425	4,884	0.9937
4,714	0.8616	4,714	0.8700	4,709	0.9061	4,750	0.9449	4,822	0.9963
4,602	0.8636	4,612	0.8719	4,612	0.9085	4,683	0.9472	4,755	0.9991
4,505	0.8653	4,505	0.8737	4,505	0.9111	4,604	0.9500	4,730[2]	1.0000[2]
4,401	0.8671	4,401	0.8756	4,431[2]	0.9128	4,580[2]	0.9508	4,696	1.0025
4,283	0.8692	4,298	0.8776	4,391	0.9146	4,494	0.9552	4,653	1.0052
4,177[2]	0.8712	4,238[2]	0.8787	4,288	0.9191	4,398	0.9607	4,617	1.0080
4,083	0.8736	4,187	0.8803	4,172	0.9248	4,309	0.9661	4,607	1.0088
3,987	0.8769	4,078	0.8841	4,018	0.9329	4,229	0.9716	4,531	1.0143
3,895	0.8801	3,987	0.8873	3,833	0.9439	4,149	0.9771	4,453	1.0198
3,786	0.8843	3,884	0.8913	3,609	0.9604	4,038	0.9853	4,375	1.0261
3,679	0.8884	3,791	0.8953	3,365	0.9826	3,905	0.9964	4,309	1.0316
3,568	0.8937	3,669	0.9007	3,131	1.0106	3,788	1.0075	4,225	1.0400
3,447	0.8991	3,568	0.9061	2,898	1.0442	3,629	1.0242	4,118	1.0511
3,350	0.9046	3,416	0.9143	2,680	1.0894	3,445	1.0466	3,988	1.0650
3,263	0.9100	3,253	0.9253	2,631	1.1008	3,284	1.0691	3,843	1.0818
3,065	0.9238	3,054	0.9419	2,521	1.1290	3,121	1.0972	3,679	1.1042
2,799	0.9488	2,838	0.9642			2,923	1.1367	3,498	1.1323
2,660	0.9655	2,641	0.9922			2,739	1.1819	3,253	1.1774
2,513	0.9880	2,454	1.0260					3,009	1.2339
2,229	1.0503	2,284	1.0685					2,808	1.2905
2,049	1.1070	2,164	1.1055					2,650	1.3474

[1]Volume at saturation pressure, 4730 psia and 189 F=1.0.
[2]Saturation pressure at indicated temperature.
[3]Specific volume at saturation pressure and 189 F=0.0333 cu ft per lb.

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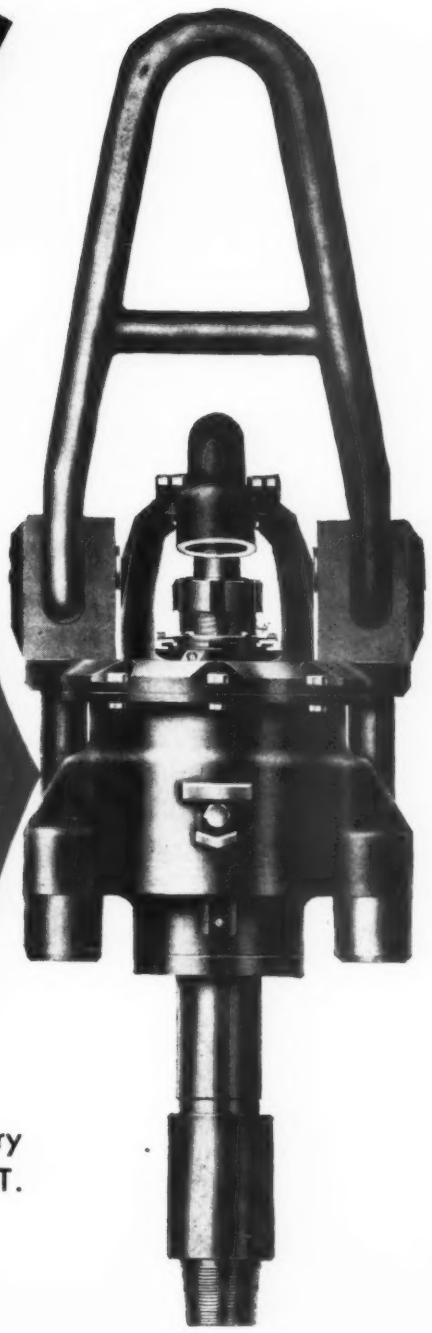

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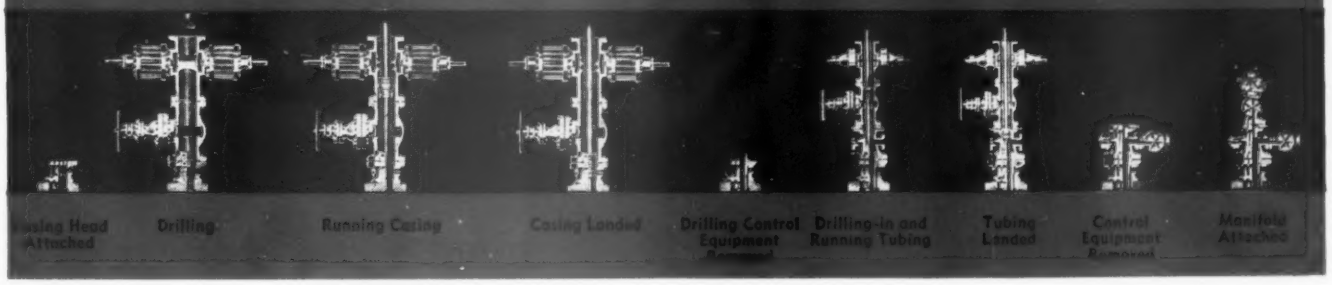


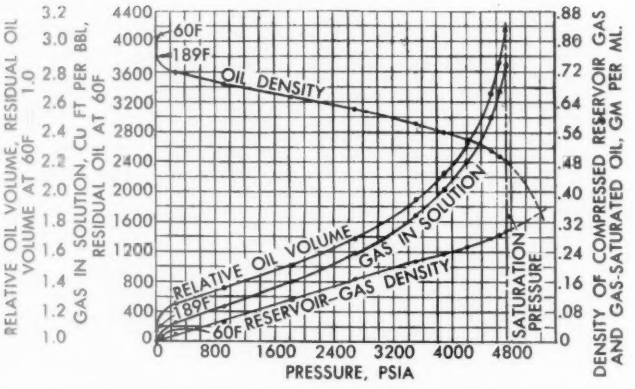
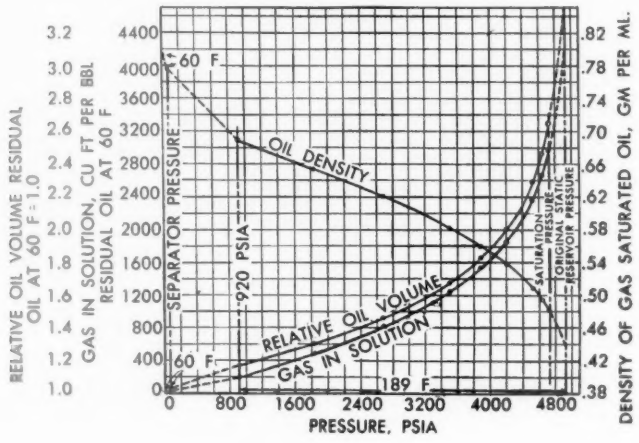


FIG. 3. Differential gas-liberation data at 189 F, subsurface oil sample, Cities Service Lawson B-1, North Lindsay field, McClain County, Oklahoma.

FIG. 4. Flash gas liberation on subsurface oil sample conducted to simulate producing conditions, Cities Service Lawson B-1, North Lindsay field, McClain County, Oklahoma.


RELATIVE OIL VOLUME RESIDUAL OIL AT 60 F = 1.0
GAS IN SOLUTION, CU FT PER BBL RESIDUAL OIL AT 60 F
DENSITY OF GAS SATURATED OIL, GM PER ML.
60 F
SEPARATOR PRESSURE
OIL DENSITY
920 PSIA
SATURATION PRESSURE
TORRICONAL STATIC RESERVOIR PRESSURE
RELATIVE OIL VOLUME
GAS IN SOLUTION
60 F
189 F
PRESSURE, PSIA

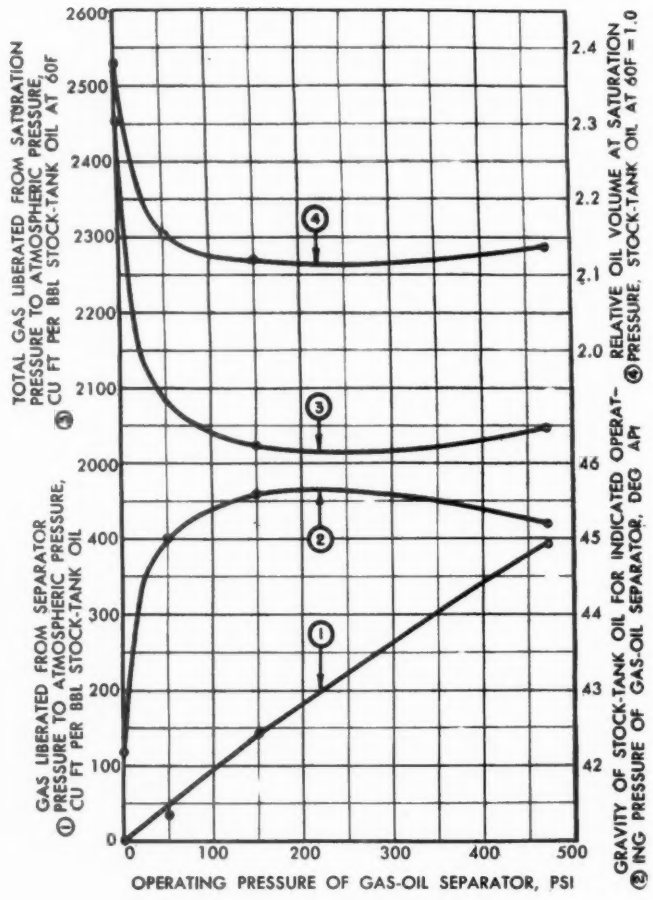

TOTAL GAS LIBERATED FROM SATURATION PRESSURE TO ATMOSPHERIC PRESSURE, CU FT PER BBL STOCK-TANK OIL AT 60F
GAS LIBERATED FROM SEPARATOR PRESSURE TO ATMOSPHERIC PRESSURE, CU FT PER BBL STOCK-TANK OIL
GRAVITY OF STOCK-TANK OIL FOR INDICATED OPERATING PRESSURE OF GAS-OIL SEPARATOR, DEG API
RELATIVE OIL VOLUME AT SATURATION PRESSURE, STOCK-TANK OIL AT 60F = 1.0
OPERATING PRESSURE OF GAS-OIL SEPARATOR, PSI

FIG. 5. Effect of different gas-oil separator pressures on the properties of stock-tank oil, Cities Service Odom 1, North Lindsay field, McClain County, Oklahoma.

arator temperatures on the volume of gas liberated from the oil. A reduction in temperature from 64 to 44 F decreased the gas-oil ratio (measured in cubic feet per barrel at 60 F) from 2502 to 2404. The data collected from November 2 to November 6 (Table 2, test 3) show that the gas-oil ratio was reduced from 2850 to 2570 cu ft per bbl when a separator operating at a pressure of 500 psi is connected in series in the flow line with the separator operating at 63 psi.

No direct comparisons are made from these flow-test data on the Lawson B-1 to show the additional quantity of oil recovered by using two separators instead of one because the accumulation of paraffin in the tubing tended to reduce the rate of production. An indirect comparison, however, can be made by referring to laboratory data on the Odom well No. 1 sample, Table 5, and noting the change in the relative oil volumes as compared to the changes in gas in solution values shown in the second and fifth flash gas-liberation experiments. The solution gas-oil ratio from saturation pressure to 64.4 psia when only the low-pressure separator was used was 2049 (2083—34) cu ft per bbl as compared to 1886 (1964—78) cu ft per bbl when both the high and low pressure sepa-

TABLE 4. Differential and flash gas-liberation data on a subsurface oil sample from Cities Service Oil Company Lawson B well No. 1, North Lindsay field.

Pressure, psia	Temperature, F	Relative oil volume, residual oil volume at 60 F = 1.0	Density[1] of liberated gas, gm/liter (gas at 60 F and 14.4 psia)	Oil density, gm/ml	Gas in solution, cu ft per bbl of residual oil at 60 F (gas at 60 F and 14.4 psia)
Differential gas liberation					
4,730[2]	189	3.073		0.481	3,694
4,646	189	2.862	1.002	0.495	3,340
4,530	189	2.657	0.987	0.510	2,986
4,208	189	2.328	0.963	0.539	2,408
3,889	189	2.128	0.948	0.560	2,039
3,506	189	1.947	0.926	0.583	1,695
2,685	189	1.694		0.621	1,188
1,837	189	1.514	0.919	0.654	808
920	189	1.358	0.906	0.689	471
271	189	1.251	0.938	0.719	254
14.4	189	1.069	1.995	0.757	0
14.4	60	1.000		0.8090	0
Flash gas liberation[3]					
4,730[2]	189	2.647		0.481[4]	2,970
4,646	189	2.465[4]		0.495[4]	2,666[4]
4,530	189	2.289[4]		0.510[4]	2,361[4]
4,208	189	2.005[4]		0.539[4]	1,863[4]
3,889	189	1.833[4]		0.560[4]	1,546[4]
3,506	189	1.677[4]		0.583[4]	1,249[4]
2,685	189	1.460[4]		0.621[4]	813[4]
1,837	189	1.304[4]		0.654[4]	484[4]
64.4[5]	60	1.028	0.905[6]	0.777	23
14.4	60	1.000	—	0.7924	0

[1]Values of gas densities are shown opposite the lowest pressure at which the gas was liberated. Gas density × 0.8344 = specific gravity (air = 1.0).
[2]Saturation pressure.
[3]Conducted to simulate producing conditions on October 29 to November 3, 1946.
[4]Calculated by using "Differential gas-liberation data."
[5]Gas-oil separator pressure.
[6]Gas liberated from saturation pressure to gas-oil separator pressure.

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TABLE 5. Results of flash gas-liberation experiments at five gas-oil separator pressures and at 60 F on a subsurface oil sample from Cities Service Oil Company Odom well No. 1, North Lindsay Field, McClain County, Oklahoma.

Pressure, psia	Temperature, F	Relative oil volume, residual oil volume at 60 F = 1.0	Density[1] of liberated gas, gm/liter (gas at 60 F and 14.4 psia)	Oil density, gm/ml	Gas in solution, cu ft per bbl of residual oil at 60 F (gas at 60 F and 14.4 psia)
Gas-oil separator pressure at zero psi					
4,335[2]	189	2.380		0.532[4]	2,453
14.4[3]	60	1.000	1.036[5]	0.8138	0
Gas-oil separator pressure at 50 psi					
4,335[2]	189	2.153		0.532[4]	2,083
64.4[3]	60	1.034	0.917[5]	0.783	34
14.4	60	1.000	—[6]	0.8009	0
Gas-oil separator pressure at 150 psi					
4,335[2]	189	2.120		0.532[4]	2,025
164[3]	60	1.076	0.870[5]	0.777	142
14.4	60	1.000	1.450[7]	0.7982	0
Gas-oil separator pressure at 472 psi					
4,335[2]	189	2.137		0.532[4]	2,047
486[3]	60	1.217	0.806[5]	0.738	393
14.4	60	1.000	1.398[7]	0.8000	0
Gas-oil separator pressures at 772 psi and 50 psi (two separators)					
4,335[2]	189	2.082		0.532[4]	1,964
786[3]	60	1.246	0.784[5]	0.727	524
64.4[3]	60	1.049	1.093[8]	0.780	78
14.4	60	1.000	1.602[7]	0.7966	0

[1]Gas density × 0.8344 = specific gravity (air = 1.0).
[2]Saturation pressure of sample at reservoir temperature (189 F).
[3]Gas-oil separator pressure.
[4]Determined in the "Differential gas-liberation experiment."
[5]Gas liberated from saturation pressure to gas-oil separator pressure.
[6]Insufficient volume of gas liberated for a gas density determination.
[7]Gas liberated from gas-oil separator pressure to atmospheric pressure.
[8]Gas liberated from a pressure of 786 to 64.4 psia.

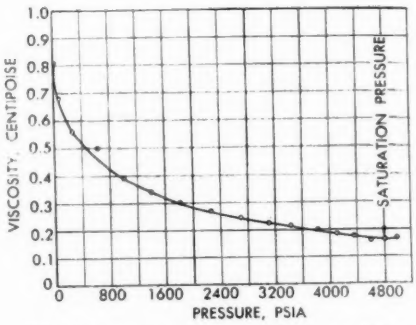

FIG. 6. Pressure-viscosities at 189 F, subsurface oil sample, Cities Service Lawson B-1, North Lindsay field, McClain County, Oklahoma.

TABLE 6. Pressure-viscosities at 189 F of a subsurface oil sample from Cities Service Oil Company Lawson B well No. 1, North Lindsay field, McClain County, Oklahoma.

Pressure, psia	Viscosity, centerpoise
4980	0.17
4805	0.16
4601	0.16
4354	0.18
4107	0.19
3827	0.20
3431	0.22
3110	0.23
2699	0.25
2259	0.27
1813	0.30
1401	0.34
1003	0.39
628	0.50
263	0.56
77	0.68
14.4	0.81

rators were used in series; the relative oil volumes at saturation pressure were 2.153 and 2.082, respectively. Thus, for a reduction in separator gas:stock-tank oil ratio of 163 (2049—1886) cu ft per bbl the increase in stock-tank oil volume was 3.4 per cent, (2.153 — 2.082) × 100/2.082. This is equivalent to a change of 2.1 per cent in stock-tank oil volume per 100 cu ft per bbl change in separator gas:stock-tank oil ratio. The effect of temperature on oil recovery is illustrated by the data in Table 2, test 2, wherein a decrease in separator temperature from 64 to 44 F reduced the gas-oil ratio 98 (2502—2404) cu ft per bbl, which should result in an increase in stock-tank oil volume of approximately 2 per cent. Likewise, as the addition of the high-pressure separator in the flow line reduced the gas-oil ratio 280 cu ft per bbl (Table 2, test 3) the increase in stock-tank oil volume would be approximately 6 per cent.

● **Effect of viscosity of oil on water movement.** The viscosity of the subsurface oil sample from the Lawson B-1 (Table 6 and Fig. 6) was 0.16 centipoise at the reservoir temperature of 189 F. The viscosity of pure water at 189 F is 0.33 centipoise[2] (the viscosity of water at 68 F is 1.0). Relatively few known reservoirs contain oil with a viscosity less than the viscosity of water at reservoir temperature. A water flood (natural or through water injection) in a reservoir containing oil of the low-viscosity type found in North Lindsay might sweep a larger portion of the reservoir, other factors being equal, than would occur in reservoirs containing normal to high viscosity oils. In a reservoir containing oil of normal viscosity, one would expect the amount of fluid flowing through the more permeable section to increase as the water "broke through" to a producing well. But, in a reservoir containing oil with a viscosity less than that of water, the amount of fluid flowing through the more permeable section probably would not increase and possibly would decrease as the water "fingered" out into the reservoir or broke through to producing

2. Hodgman, Charles D., *Handbook of Chemistry and Physics:* Chemical Rubber Publishing Co., Cleveland, Ohio, 21st Edition, 1936-1937, pp. 1226, 1227. Interpolated from data of Bingham and Jackson.

TABLE 7. Fractional analyses of oil and gas samples, North Lindsay field, McClain County, Oklahoma.

Component	Mole fraction			
	Subsurface oil sample[1]	Separator oil sample[1,2]	Separator gas sample[1,2]	Reservoir gas sample[3]
Carbon dioxide	0.0028		0.0020	0.0066
Nitrogen	0.0042		0.0095	0.0075
Methane	0.6206	0.0055[4]	0.7633	0.7727
Ethane	0.0950	0.0114	0.1124	0.0809
Propane	0.0619	0.0360	0.0665	0.0465
Isobutane	0.0128	0.0141	0.0116	0.0076
Normal butane	0.0254	0.0473	0.0204	0.0185
Isopentane	0.0098	0.0195	0.0042	0.0059
Normal pentane	0.0139	0.0561	0.0059	0.0135
Hexanes	0.0226	0.0893	0.0030	0.0064
Heptanes plus	0.1310	0.7208	0.0012	0.0339
Specific gravity of C_7+residue	0.8183	0.8251	—[5]	0.74[6]
Mol wt. of C_7+residue	180	172	—[5]	130[6]

[1]Samples from Cities Service Oil Company Lawson B well no. 1.
[2]Separator pressure = 47 psi. Separator temperature = 60 F.
[3]A subsurface sample from the Cities Service Oil Company Robinson well no. 1 contained both oil and free gas. This free gas was separated from the reservoir oil in the laboratory at reservoir conditions of 4178 psia and 189 F.
[4]Methane and lighter. [5]Insufficient residue for determination of this value. [6]Estimated.

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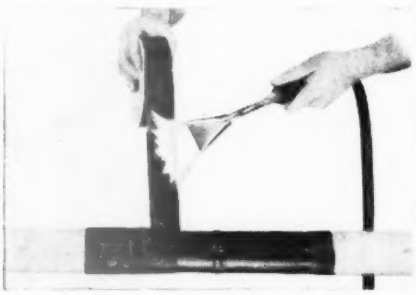
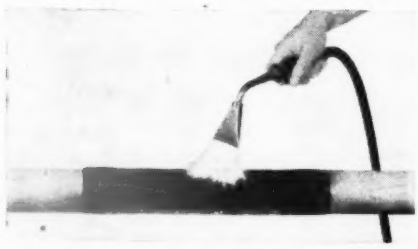
A practical, protective coating in handy tape form, TAPECOAT is easy to apply on pipe joints to give protection equivalent to the mill or machine coating on the pipe. It's clean—no dirt, no mess. Saves time and labor. Economical. Here's all you do:

STEP 1—Remove kraft paper on mill or machine coating back far enough to start one spiral wrapping of TAPECOAT over mill coating. Clean and dry bare pipe with torch as shown.



STEP 2—Start wrapping TAPECOAT where kraft paper has been removed. Flash flame of torch *lightly* on TAPECOAT to bleed its coating. Secure double thickness of TAPECOAT by overlapping slightly more than half the width of the tape.



STEP 3—Finish wrapping TAPECOAT. When wrapping is completed, flash the torch flame over entire TAPECOATED section to bleed coating to a shiny surface.

Write for complete details

The TAPECOAT Company
1523 Lyons St., Evanston, Illinois

TABLE 8. Analysis of crude oil from Cities Service Oil Company Lawson B well No. 1, North Lindsay field, McClain County, Oklahoma.

Sample 47039

General characteristics

Specific gravity, 0.793 — API gravity, 46.9°
Sulphur, per cent, less than 0.1 — Color, NPA no. 4½
Saybolt Universal viscosity at 100 F, 34 sec.

Distillation, Bureau of Mines Hempel Method

Distillation at atmospheric pressure, 748 mm first drop, 28 C. (82 F)

Fraction no.	Cut at C	Cut at F	Per cent	Sum per cent	Sp gr, 60/60 F	°API 60 F	CI	Aniline point, °C	S. U. viscosity, 100 F	Cloud test, F
1	50	122	4.1	4.1	0.633	92.0	–	48.4		
2	75	167	4.5	8.6	0.664	81.6	4.6	57.0		
3	100	212	7.0	15.6	0.708	68.4	16	55.8		
4	125	257	8.5	24.1	0.737	60.5	20	53.6		
5	150	302	7.3	31.4	0.756	55.7	22	54.3		
6	175	347	7.1	38.5	0.772	51.8	23	56.8		
7	200	392	5.7	44.2	0.785	48.8	23	61.1		
8	225	437	5.8	50.0	0.798	45.8	23	66.6		
9	250	482	5.9	55.9	0.812	42.8	24	71.0		
10	275	527	6.4	62.3	0.824	40.2	25	74.5		
Distillation continued at 40 mm.										
11	200	392	3.5	65.8	0.840	37.0	29	80.8	41	20
12	225	437	5.8	71.6	0.845	36.0	28	85.3	45	40
13	250	482	5.0	76.6	0.859	33.2	31	89.4	56	60
14	275	527	4.1	80.7	0.866	31.9	31	94.4	76	70
15	300	572	4.4	85.1	0.872	30.8	31	99.6	125	90
Residuum			12.5	97.6	0.908	24.3		114.4		

Carbon residue of residuum, 1.4 per cent; carbon residue of crude, 0.2 per cent.

Approximate summary

	Per cent	Specific gravity	°API	Viscosity
Light gasoline	15.6	0.676	77.8	
Total gasoline and naphtha	44.2	0.730	62.3	
Kerosine distillate	18.1	0.812	42.8	
Gas oil	8.9	0.843	36.4	
Nonviscous lubricating distillate	9.6	0.851–0.869	34.8–31.3	50–100
Medium lubricating distillate	4.3	0.869–0.875	31.3–30.2	100–200
Viscous lubricating distillate	—	—	—	Above 200
Residuum	12.5	0.908	24.3	
Distillation loss	2.4			

wells. Thus, when considering only viscosity, one would expect a more uniform water front when the viscosity of the reservoir oil was less than that of water.

● **Comparison of reservoir oil with gas from condensate-bearing reservoirs.** Production and laboratory data may suggest that the physical properties of the reservoir oils in the North Lindsay field are similar to those of gas in some condensate-bearing reservoirs. Densities of the gases that have or will be liberated in the reservoir were calculated for several reservoir pressures below the saturation pressure of the subsurface oil sample from the Lawson B-1. These densities, plotted on the same scale as the density of the reservoir oil, are shown in Fig. 3. When the gas-density and oil-density curves are extrapolated to higher pressures they intersect at a pressure of approximately 5200 psia. This indicates that if gas of the correct composition were added to and absorbed by the reservoir oil through increased pressure and agitation, when the saturation pressure of the reservoir oil reached 5200 psia the density of the gas and oil would be identical and the mixture would be at the critical pressure. It is probable also that the reservoir oil could be changed into the gaseous phase with increasing the temperature much less than would be required for most reservoir oils. The "Locus of saturation pressures" curve of the subsurface oil sample (Fig. 2) is concave downward, indicating that the maximum saturation pressure would not be much greater than that shown at 189 F.

Table 7 gives the composition of the reservoir oil and that of the free gas in the reservoir. The Hempel type analysis of stock-tank oil is given in Table 8.

● **Acknowledgments.** This study was conducted by the Bureau of Mines Petroleum Experiment Station, Bartlesville, Oklahoma, in cooperation with the State of Oklahoma.

The authors gratefully acknowledge the cooperation given by C. E. Beecher, J. R. Hatfield, F. A. Lichtenheld, and G. E. Hendrickson of the Cities Service Oil Company, in making wells available for subsurface oil sampling and for providing pertinent geological, well completion, and production data. Thanks are extended to W. H. Barlow and W. B. Berwald, Ohio Oil Company, G. E. Hendrickson, Cities Service Oil Company, and C. B. Carpenter, H. C. Miller, R. H. Espach, and E. M. Tignor, Bureau of Mines, for criticisms and suggestions that were helpful in the preparation of the final report.

The study was under the supervision of R. A. Cattell, chief, Petroleum and Natural Gas Branch, and H. C. Fowler, supervising engineer, and C. J. Wilhelm, engineer in charge of production, Petroleum Experiment Station, Bartlesville, Oklahoma.

* * *

Research octane numbers show improvement

Report of American Chemical Society Meeting by ARCH L. FOSTER, *Refining Editor*

In the improvement of performance and economy of automotive engines the increase in compression ratio, with corresponding increases in octane rating of fuels supplied is the natural and the best method to employ, chemists and engineers before the American Chemical Society meeting in St. Louis September 6-10 have stated. In the improvement of anti-knock rating of motor fuels, the research octane rating is more important. The increase in requirement in motor method rating, as economy, miles per gallon, and performance are stepped up, is lower, and slower, than is the need for increase in research octane ratings, it is found.

This fact is an advantageous one for the petroleum, and therefore for the automotive industry, reports R. W. Scott, G. S. Tobias, and P. L. Haines of Esso Laboratories, who gave results of tests to determine anti-knock requirements of high compression ratio engines as of 1948. The "laboratory appreciation" of fuels, that is, the difference between the motor and the research method ratings, is greatest for fuels containing relatively large amounts of aromatics, naphthenic, and isoparaffinic components. These components are produced best and most economically by catalytic cracking, polyforming, hydroforming, polymerizing processes, which are most in use by the refining industry today. Therefore these processes are most advantageous in producing these most desirable components at the lowest cost and highest yields, these investigators say.

If the reverse condition were true, that is, if motor method ratings were the more limiting on fuel performance and/or economy, it would be necessary that the refining industry adopt more restrictive processes that give lower yields of the required octane rating products, thus resulting in lower over-all production of motor fuels than that which can be realized by catalytic and similar methods now employed. One of the conditions that permits higher yields of desirable motor fuels by catalytic cracking, catalytic alkylation, and similar processes is that catalytically cracked motor fuels show little if any decrease in the octane rating of the heavier — higher boiling — components, since aromatics, naphthenes, and isoparaffins predominate in the heavier fractions of these products. Distillates from thermal cracking show greatly decreased octane ratings in the higher boiling constituents, thus limiting the end-points of fuels composed mainly of thermally cracked materials, which reduces the yield correspondingly.

Fuels of 79 and 90 motor and research method ratings, respectively, satisfy high speed needs of 8:1 compression ratio engines, but in one case low speed needs were met by adding more than two cc. of TEL to the base fuels, Scott and colleagues found. Compression ratios of 10:1 were supplied satisfactorily by fuels showing motor rating of 87.1 and 88.5, research ratings of 100.5 and 100.0. A compression ratio of 12.5:1, corresponding to the ratio employed in the General Motors experimental engine announced in 1947, was satisfied by a fuel showing 100 research and 88.5 motor ratings. Research rating correlate best with road ratings at low speeds, while motor ratings correlate well with higher speed road ratings.

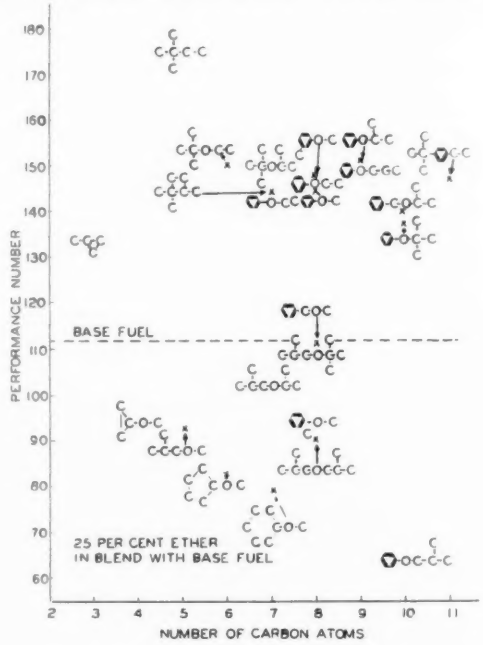
Replacement of the olefins, paraffins, and naphthenes in the heavier half of the fuel distillation range produces a rise in the road octane-speed curve over the entire speed range, but especially in the lower speeds, W. E. Offutt, J. E. Taylor, and G. B. Swartz, Jr., Gulf Research and Development Company found by exhaustive research. Fuels for future high-compression ratio engines should be rated only in specially designed, high compression engines, which preferably should be of the production type, these researchers say, if the ratings are to be of any significance. Conventional engines with stepped-up ratios rated fuels at lower values than did specially designed high compression ratio engines, they found. The road octane rating of fuels appears to increase with compression ratio increase, data show.

▸ **Engine efficiency increases with compression ratio increase.** Fuel economy increases of up to 40 per cent are practicable by increasing compression ratios up to 12.5 to 1, if suitable non-knocking fuels are available for these engines, J. M. Campbell and L. L. Withrow of General Motors Research Laboratories pointed out, referring to statements and data made public by Kettering in 1947, and later revelations. Increases of 30 per cent in ton-miles per gallon of fuel were made from 1930 to 1947, when ratios were raised from about 5:1, to about 6.7:1. Of this increase the automotive and the oil industries were each responsible for approximately half of the total, they said. The automotive engine has increased economy by some 18 per cent by improvements in spark ignition mechanisms, carburetion and fuel distribution in multicylinder engines. Increases in octane ratings have preceded the raises of compression ratio, a sequence that is necessary if the engines are to perform satisfactorily. Additional advances must be made by the automotive industry, such as in fuel distribution, leaning out fuel-air mixtures and in transmission mechanisms. The improvement in economy made possible by raising compression ratios effects a saving that will more than pay for the added cost of refining the required motor fuels, Campbell and Withrow believe.

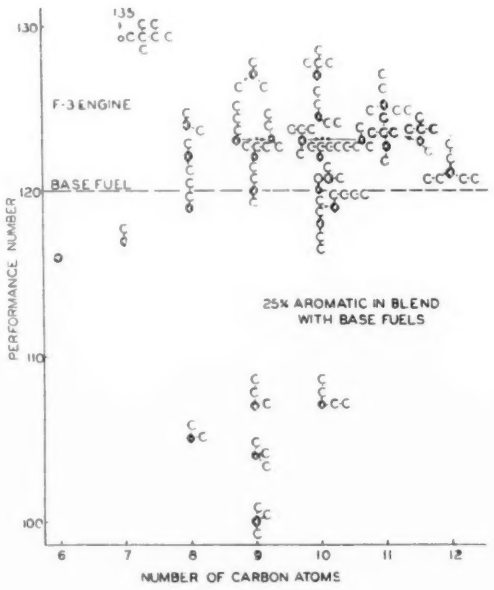
▸ **Synthetic gasolines high in olefins.** Synthetic motor fuels by the Hydrocol process are highly olefinic and high in octane ratings, in contrast to the liquid fuels produced in Germany during the war, says F. H. Bruner of The Texas Company. The difference is caused by the difference in the catalyst used in this country and in the conditions of operation, Bruner stated. The American process (Hydrocol) uses a sintered, low cost, finely divided iron catalyst, while the Germans used a catalyst composed in large degree of cobalt; the two catalysts have different effects in synthesis operations, experience has shown.

Tests show that the addition of Hydrocol gasoline to motor fuels improves the low speed octane rating of the blend; also it is shown that the effect of TEL addition is small. Three cc. of TEL added to 80.2 motor octane number Hydrocol naphtha raised its motor method rating to only 84.1, or 3.9 numbers, whereas the same amount of TEL raised a 50-50 mixture of thermally cracked and straightrun fuels from 48.3 to 67.2, or 18.9 numbers. This result is to be expected from the high olefinic content of the Hydrocol product, the acid heat value of which is 234 F. One good feature of the high olefinicity of the Hydrocol fuel is that

Knock performance of ethers—Barnett and Drell.



Knock performance of aromatics—Barnett and Drell.



the C_3-C_4 fraction can be polymerized to lower volatility and about equally high octane ratings, to increase considerably the over-all yield of motor fuel.

Effect of aromatic blends on aviation fuel performance. Addition of aromatics, up to about 25 per cent in aviation fuel blends, increases the power output in varying percentages, H. C. Barnett and I. L. Drell, reported after extensive research. Base fuel consisted of 87.5 per cent isooctane in 12.5 per cent n-heptane. Aromatics of high purity were blended with this base fuel, 25 per cent of aromatic component and 75 per cent base fuel, which is considered about the maximum proportion of aromatics in a practical blend. This series of blends are each given 4 cc. of TEL.

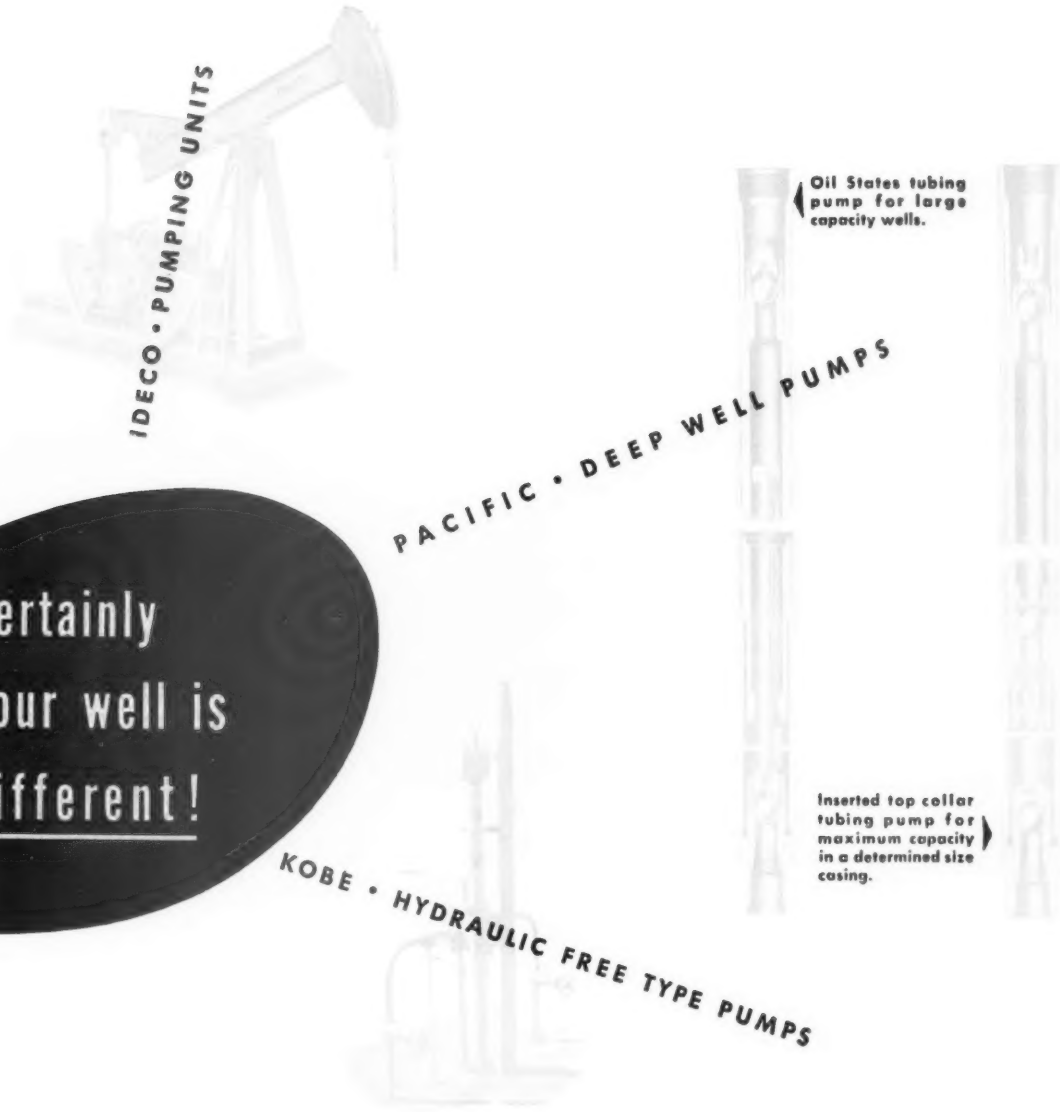
Under full scale cruise conditions the benzene blend showed 20 per cent more power until limited by knock; toluene showed 28 per cent more power, ethylbenzene 35 per cent more, an n-propylbenzene 47 per cent more power. Strangely, n-butylbenzene showed only 11 per cent more power than the base fuel. Of the several butylbenzenes, tertiary-butylbenzene showed the highest power increase. Among dialkyl substituted benzenes, it appears that the meta-forms show somewhat better power improvement than others. The relative performance ratings of these aromatics tested are shown in the accompanying figure.

Similar blends of base fuel, performance number 120 as used with aromatics, with various ethers such as methyl-tertiary butyl, ethyl and i-propyltertiary butyl, anisole, etc., in proportions up to 50 per cent ether, show greater power improvements, up to 160 per formance number in the case of 50 per cent i-propyl and 150 for the methyl and ethyl ethers, as shown in the accompanying curves; and about 174 for methyl-i-butyl ether. The advantages of both types of blending agents are plain to see from the data presented.

Blend octane numbers may be estimated—calculated—from the octane ratings of the components by a simple method with a high degree of accuracy, if the octane ratings of components are known, J. C. Bogen and R. M. Nichols of Universal Oil Products Company reported. The method is one of obtaining the product of the octane rating of each unsaturated component by its percentage in the mixture of unsaturates, adding these increments, adding thereto a value taken from curves that were developed, to give the increase in blending octane rating above the linear value for the pure fraction; adding to this sum the linear value of the straight-run component, which is accepted as equal to its blending value, multiplied by its percentage in the blend; the aggregate is the calculated rating of the blend. The results shown indicate that the calculated value is within a very few tenths of an octane number to the actual engine-determined value.

Analysis of a catalytically cracked gasoline showed 4-5 per cent normal paraffins, 40-45 per cent isoparaffins, 16-20 per cent cycloparaffins, 31-32 per cent aromatics and 4-5 per cent olefins, according to results obtained by A. R. Glasgow, Jr., C. B. Willingham, and F. D. Rossini of the Bureau of Standards. The specific sample reported on was produced in a Houdry fixed-bed type of catalytic cracker. The aromatic portion showed the presence of determinable and appreciable amounts of mono-and polyalkyl substituted benzenes, C_{10} aromatics and higher. Altogether more than 60 different hydrocarbons, including olefins, were isolated and determined quantitatively.

Satisfactory, stable catalysts for reforming naphthas in the presence of hydrogen—Hydroforming principle—have been developed and tested by E. C. Hughes, H. M. Stine and S. M. Darling of Standard Oil Company (Ohio), composed of 20 per cent chromium oxide and 80 per cent aluminum oxide (Chromia-Alumina), these researchers reported. After stabilization treatment these new catalysts showed activity and catalyst life comparable to that shown by the commercial molybdena-alumina catalysts in general use in Hydroforming plants. Catalyst activity dropped rapidly for a time, but the curve of activity flattened out to show a very slow reduction, which was accepted as indicating satisfactory life. Test runs with naphthas fortified with sulphur compounds showed no loss of catalyst activity, indicating that the catalyst is satisfactory with high-sulphur stocks for this process. * * *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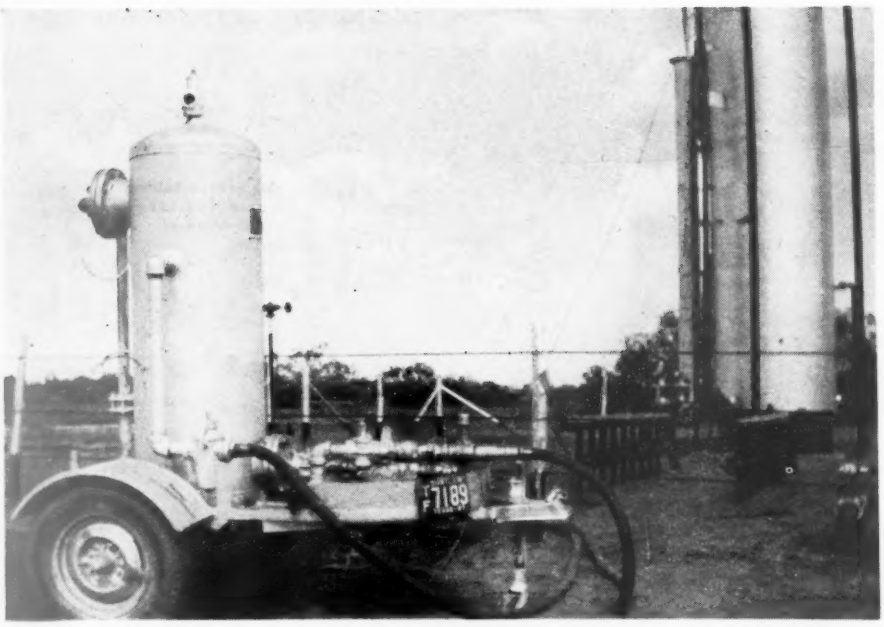


Oil, gas, and water production from individual wells is measured by this trailer-mounted well testing unit at a central tank battery.

Well Testing Units Cut Cost

By K. MARSHALL FAGIN, *Field Editor*

EXCLUSIVE

ALTHOUGH portable oil well testing units of one kind or another have been used for many years for measuring the production of oil, gas, and water from individual wells, the systematic use of such devices by certain operators of marginal or stripper wells at the present time is enabling them to weed out and abandon wells that have ceased to produce enough to pay their way, thus reducing the cost of operating the remaining wells, and allowing the operators to take advantage of the high-priced market for used casing and supplies.

One operator of about 2000 shallow wells in North Texas has found it profitable to use one of these portable testing units and an operator on a continuous survey of the production from his properties. The unit is moved from well to well and lease to lease for 24-hr production tests. The operator makes minor repairs to well and lease equipment, and improves the appearance of the property while the well tests are in progress.

Table 1 shows the results obtained by this operator from the production tests made on two leases that are being waterflooded. It is interesting to note that most of the oil production from lease "A" comes from two wells, and that three wells have been marked for abandonment. Two other wells appear to be flooded, but the operator must expect them to begin producing oil again. Well No. 9 on lease "B" is another one that may begin to produce oil after enough water is pumped off. Well No. 7, lease "B" is apparently about through producing oil, and may be marked for abandonment after the next survey.

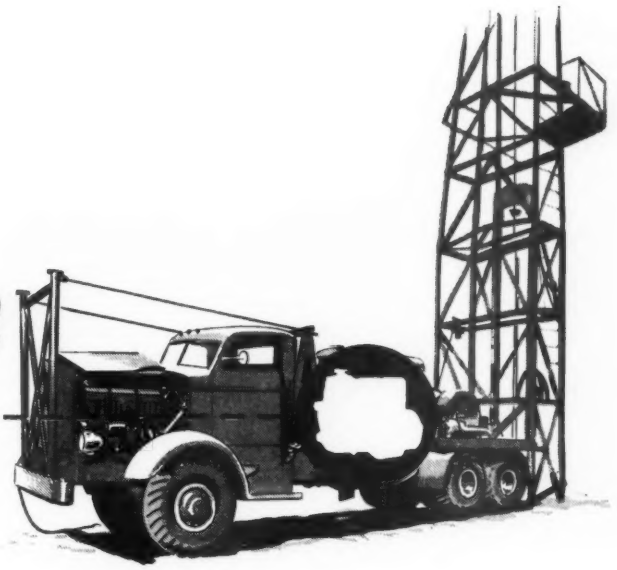
Surveys of this kind often reveal large discrepancies between the potential producing capacity of a lease and the daily average production. Lease "A", for example, should have produced about 10 bbl more per day than it did during the month of January. Perhaps this discrepancy was due to some of the wells being shut down for repair, or to a change in waterflood conditions. Whatever the cause, a survey of this kind indicates the quantity of oil that might be produced from a group of wells if each is produced as many hours every day as it was on the test. It also indicates how many wells can be abandoned without materially reducing the production.

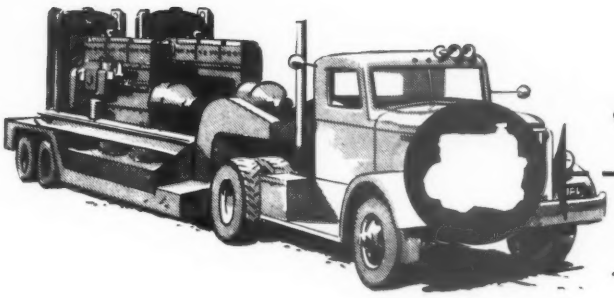
Portable well testing units are now in regular use by many other operators, especially on leases where flow lines are not arranged for testing wells individually. Various types and sizes of portable testing units have been designed and are available for measuring the oil, gas, and water production from individual pumping or flowing

TABLE 1. Result of 24-hr production tests of shallow wells being waterflooded.

Well no.	Date	24-hr gauge, bbl		Remarks
		Oil	Water	
Lease "A"				
19	1- 7-48	10.0	80.4	
9	1- 9-48	0.	56.4	
27	1-10-48	0.	26.3	This well should be plugged.
20	1-11-48	0.	51.3	
26	1-12-48	0.	0.	This well should be plugged.
24	1-13-48	1.0	13.4	
22	1-14-48	5.0	51.7	
2	1-15-48	4.0	10.1	
13	1-16-48	4.0	7.5	
12	1-20-48	15.0	32.2	
3	1-21-48	0.5	7.0	Well pumped off in 5 hr.
5	1-22-48	0.	8.0	This well should be plugged.
29	1-23-48	1.0	7.0	Well pumped off in 8 hr.
	Total. . . .	40.5	316.7	
Actual oil produced, 30 bbl daily (average during January, 1948.)				
Lease "B"				
13	2-14-48	3.8	19.4	
11	2-15-48	5.0	15.2	
4	2-16-48	9.2	23.2	
7	2-17-48	0.	21.8	Pumper claims this well seldom shows any oil.
10	2-18-48	1.3	9.6	Well pumped off in 10 hr.
3	2-19-48	2.5	17.5	
1	2-20-48	6.0	18.2	Well pumped off in 18 hr.
15	2-25-48	1.0	33.1	
9	2-29-48	0.	33.3	This well had been off for several weeks.
	Total. . .	28.8	196.3	
Actual oil produced, 22 bbl daily (average during February, 1948.)				

Watch this space





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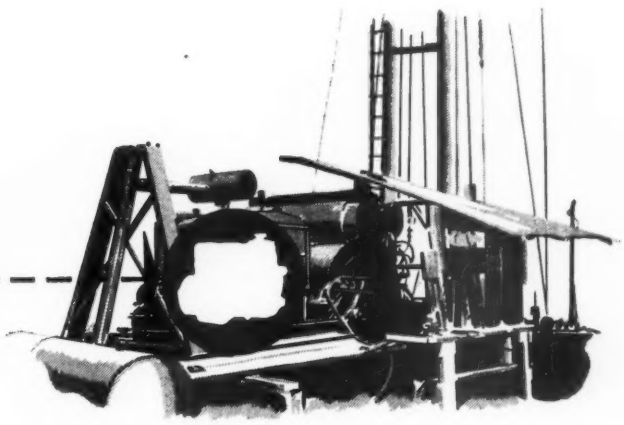

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wells. The operator of the stripper wells referred to above uses a unit mounted on a light two-wheel trailer. It is similar in appearance to the ones shown in the accompanying photos.

The testing unit assembly for stripper wells includes a 44-in. by 14-in. gas trap, a positive displacement liquid meter and proportional sampling device, an orifice meter, flexible hoses, and auxiliary equipment and connections. The gas trap has a 24-hr capacity of about 200 bbl of oil and 300,000 cu ft of gas at a pressure of 25 psig. It is equipped with a liquid level gauge glass, a pressure relief valve, and a liquid level float control that can be adjusted to give snap or throttling action performance. Maximum working pressure of the trap is 125 psig.

The positive displacement meter is similar to the meters used in gasoline dispensing pumps and is equipped with a counting mechanism calibrated in gal. It has a capacity of about 25 gpm or 35 bbl per hr with a pressure differential of 6 psi. The maximum working pressure is 125 psig.

The automatic sampling device is actuated by the meter counting mechanism and takes a proportional sample out of every one-tenth bbl of liquid that passes through the meter. The amount of each sample can be regulated so that the capacity of the sample jar will not be exceeded during a 24-hr test. The percentage of clean oil in the sample jar times the barrels of liquid produced through the meter is usually a very close gauge of an individual well's production.

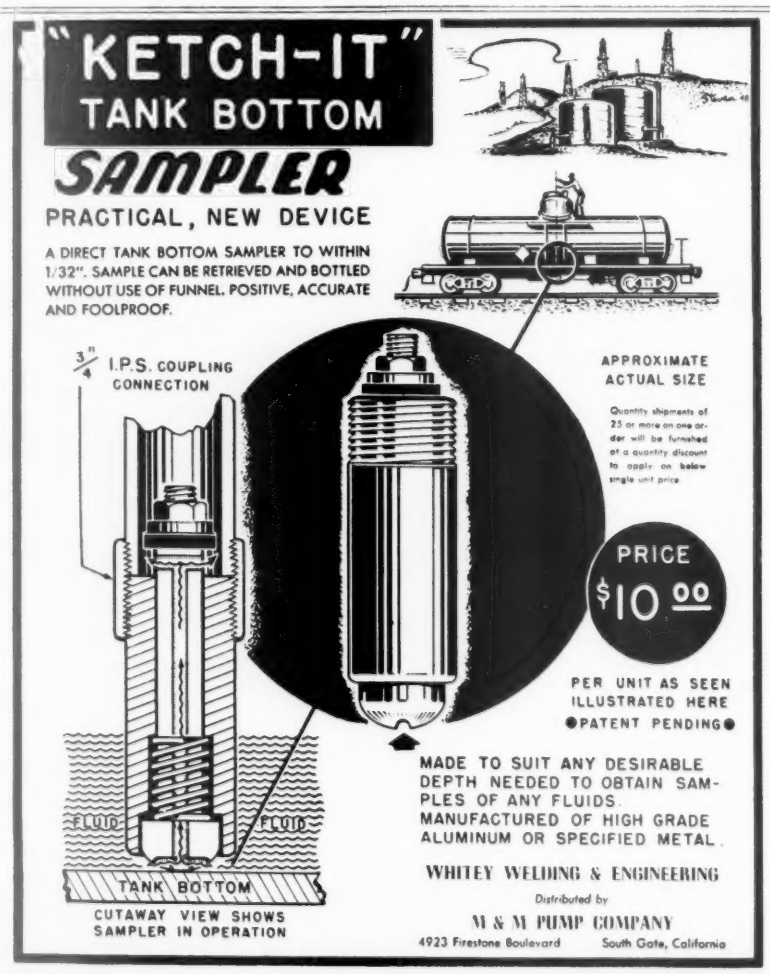
Portable well testing unit measuring the production from a well in the North Texas area. Note that flexible hoses are used in making connections.

The gas production can be measured by an orifice meter connected to an orifice flange inserted in the gas outlet pipe from the trap. Measurement of gas from many stripper wells is often dispensed with as being unnecessary, but the testing units are usually equipped with orifice meters so that gas production may be measured even under a vacuum.

The portable testing units are equipped with flexible hoses of sufficient length to connect the units to the lead lines at the wells or to lead lines at central tank battery manifolds. The individual well's production passes through the unit where it is separated, measured, and sampled. The liquid passes on into the regular flow line. The gas may be either vented through a flexible hose or also injected into the regular flow line.

Portable well testing units of the capacity described above weigh about 450 lb complete, including the trailer, and can be handled easily by conventional trailer towing connections attached to field cars or trucks.

Such units can be utilized effectively by operators of water floods and gas repressuring projects to make regular surveys of their producing wells and thus determine the progress of their operations. Decisions based on data obtained through regular 24-hr per well surveys with devices of this kind are apt to result in the production of more oil with less lost motion and expense than decisions based on periodic or irregular "spot" tests taken over shorter periods of time. ★ ★ ★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CUTAWAY VIEW SHOWS SAMPLER IN OPERATION

How to Use Diamond Bits in Deep Drilling

This material was prepared under the auspices of the Toolmakers and Research Committees of the Industrial Diamond Association of America, Inc., through whose cooperation the text was made available to The Petroleum Engineer.

WITHIN the last 18 months, a new and extensive use has been found for diamonds in the oil fields. Although the use of diamond bits in deep drilling is by no means new, the original work was done with carbonados, in the early 1920's, and the cost was high. With the development of hard metal rock bits the use of diamonds virtually terminated because it was found possible to penetrate reasonably hard formations, which had previously proved too hard for drag, or blade type, bits. The mining industry was not able to use rock bits to any extent, however, and so the use of diamond bits for exploration was continued, and drilling techniques were gradually improved over the years.

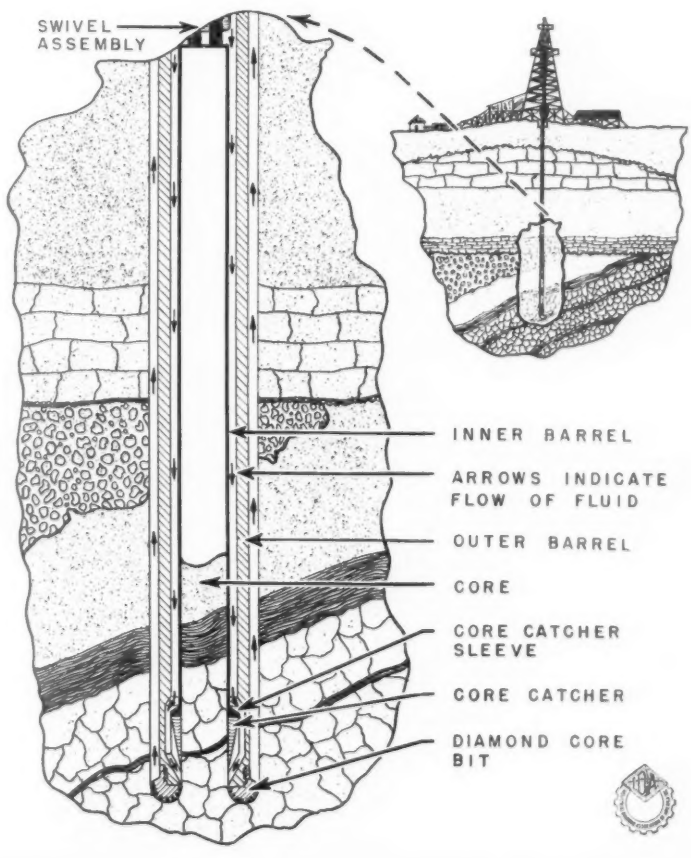
▸ **Prior developments.** By 1938 almost all diamond bits were mechanically set and considerable research and experimentation has been going on since that time. It was soon demonstrated that diamonds of various grades and sizes set in different patterns gave the lowest drilling costs when applied to different rock formations; and allied to this development in bits, improvements had also been made in diamond drills with a trend toward increased rotational speed.

Diamond drill holes, in general, are not deep compared to oil field drilling, but in several instances quite deep holes were drilled, and in one case a hole of more than 10,000 ft was completed successfully. By 1942 a group of men in the industrial diamond industry, began to exchange views with men in the production end of the oil business regarding the possibility of using diamond drilling techniques at great depth. Experiments were undertaken at that time, but progress was slow for two reasons. The United States was at war so that very little time could be devoted to this development, and the cost of the experimentation was so great that each step had to be very carefully considered.

▸ **Modified bits and techniques are used.** It was quickly found that certain of the principles of diamond drilling, as we know them, remain the same when attempting to drill holes 10,000 and 12,000 ft deep, but because of the size of the bits, many drastic modifications were necessary. For instance, in conventional diamond drilling, there is a wide range of rotational speed available on a diamond drill and, furthermore, the means of advancing the bit is mechanically controlled either by a screw feed mechanism or by hydraulics. In the oil field, the drilling rigs that are in general use do not yet incorporate such desirable features. The bit is fed by the weight of the drill pipe above it being lowered, and this is done by spooling a line off a drum. The rate of feed is controlled by a brake on the drum. An even rate of feed and a constant weight on the bit are thus difficult to attain. An added factor was the fact that rotational speeds common in diamond drilling were not obtainable on the equipment available in the oil fields.

▸ **Limits of weight on bits.** As we know, diamonds are brittle and are therefore vulnerable to percussion. They will also burn readily through excessive friction when in contact with an abrasive, unless they are ade-

FIG. A. Operating principles of diamond core bit and core barrel.



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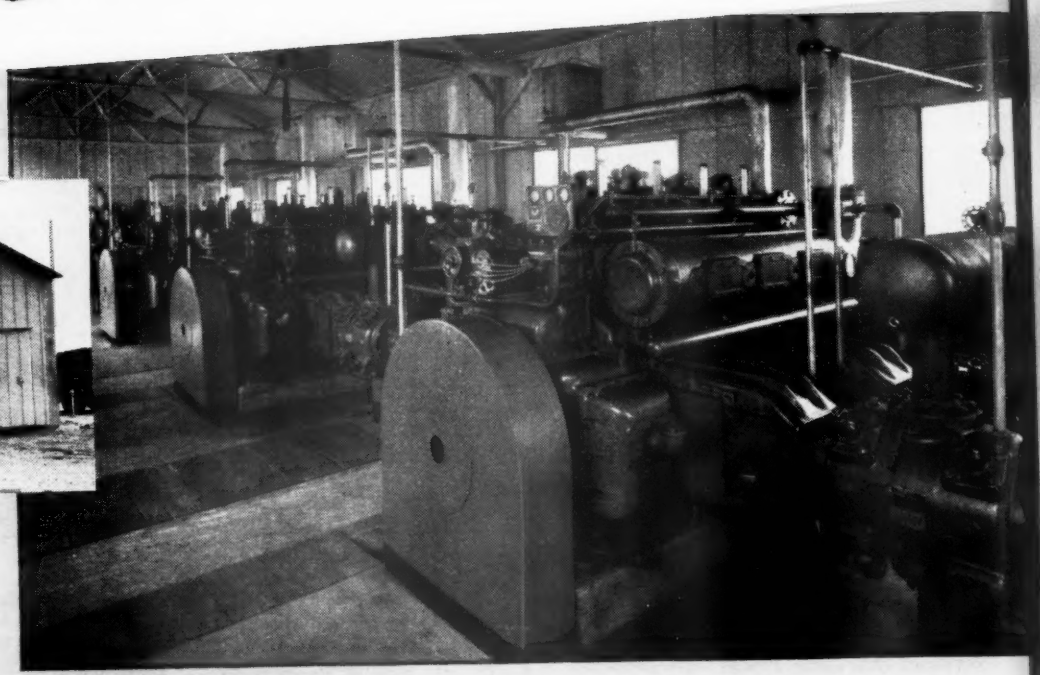
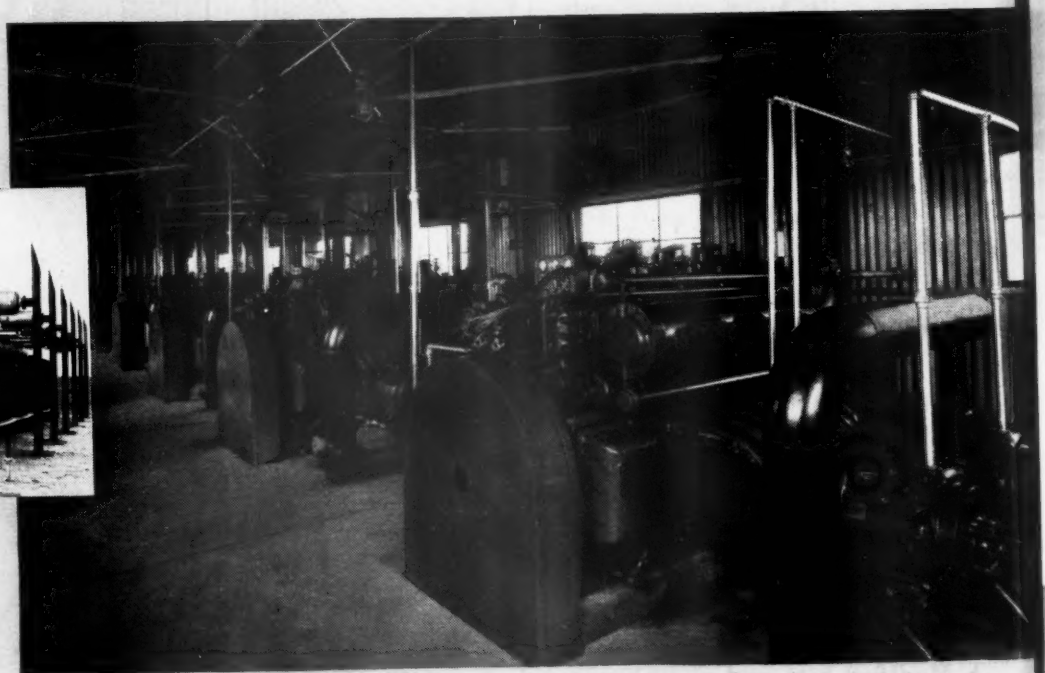
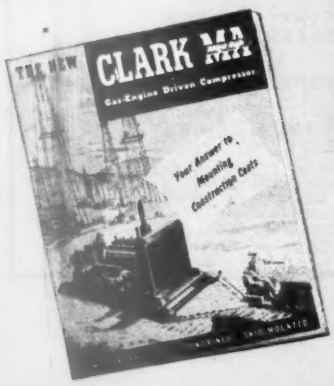


4 Clark 4-cylinder 150 B.H.P. "Midget Angle" Compressors at Consolidated Gas Utilities Corp. plant No. 1 at Magic City, Texas. Daily capacity is 7,800,000 cubic feet.

6 Clark 4-cylinder 150 B.H.P. "Midget Angle" Compressors at plant No. 2, Magic City, Texas. Daily capacity is 11,700,000 cubic feet. Note small floor space and light foundations required.





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Taking gas at 35 PSI suction pressure and discharging it at 135 PSI pressure, four 4-cylinder 150 B.H.P. Clark "Midget Angle" Compressors have a daily capacity of 7,800,000 cubic feet at their No. 1 plant. At their No. 2 plant, six 4-cylinder 150 B.H.P. "Midget Angles" have a daily capacity of 11,700,000 cubic feet.

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quately cooled. Rock bits can withstand downward thrust of more than 35,000 lb, but it was soon found that 10,000 lb of weight on a diamond bit of 6-in. diam was the economic limit. This necessitated a revision of drilling technique, but the final result was gratifying in that light weight on the bits tended to keep the holes straighter in certain formations.

▸ **Circulating fluids.** Apart from the considerations of rotating the bit correctly and keeping a constant rate of feed and weight upon it, the question of circulating fluid had to be considered. In drilling very deep holes, it is usually the practice to set casing for part of the depth, but to leave the hole open below the bottom of the casing. It is, therefore, necessary to make sure that the wall of the hole stands up, and in order to do this a type of mud is used containing materials that attach themselves to the wall of the hole and form a cake. This mud, in almost all instances, also contains material that greatly increases its weight, and this factor is important in preventing blowouts when high pressures of gas and oil are encountered. (Fig. A).

▸ **Development of drilling muds.** The development of drilling mud is one of the principal factors in reducing wastage from blowouts, which were common in the early days of oil drilling. This circulating fluid, however, is by no means the ideal coolant for a diamond bit. In conventional diamond drilling water is used to keep the bit cool and to wash away the cuttings. The volume of fluid passing over the face of the bit is not considered, provided it is sufficient to perform these two functions; and the velocity of the water is seldom sufficient to cause erosion of the matrix that holds the diamonds in place. In drilling oil wells, certain drilling mud characteristics must be maintained in order to keep the hole in condition, and this is its primary objective. It also serves to wash away the cuttings and keep the bit cool, but it does so in a relatively inefficient manner. Because the mud is expensive, it is used over and over again, and quickly picks up abrasive particles; so that it is a problem to control the erosive action caused by large volumes of fluid being forced through small water courses on the bit face. This difficulty has been overcome by suitable designs of bits and by metallurgical research aimed at increasing the anti-abrasive qualities of the matrix metal.

▸ **Preserving diamond life.** The diamonds themselves, when properly applied to the rock formations and adequately cooled, will last for a long time. Eventually a flat spot is worn, and it is then time for resetting. In most cases, however, the potential life of the diamonds is shortened by operational hazards. Apart from excessive weight due to irregular feeding, and burning due to the rotational speed not being synchronized with the weight, the greatest difficulty has been in keeping the drill hole free of foreign objects. Rock bit bearings, rock bit teeth or cones, and many other fragments frequently get broken up while drilling the upper part of the hole, and they are difficult to remove once they break loose. Any metal in the hole is likely to damage a diamond bit and satisfactory results are most difficult to obtain unless the hole is clean. (Fig. H).

▸ **Diamond sizes and bit design.** As in conventional diamond drilling, it has been found in deep oil field drilling that different sizes and kinds

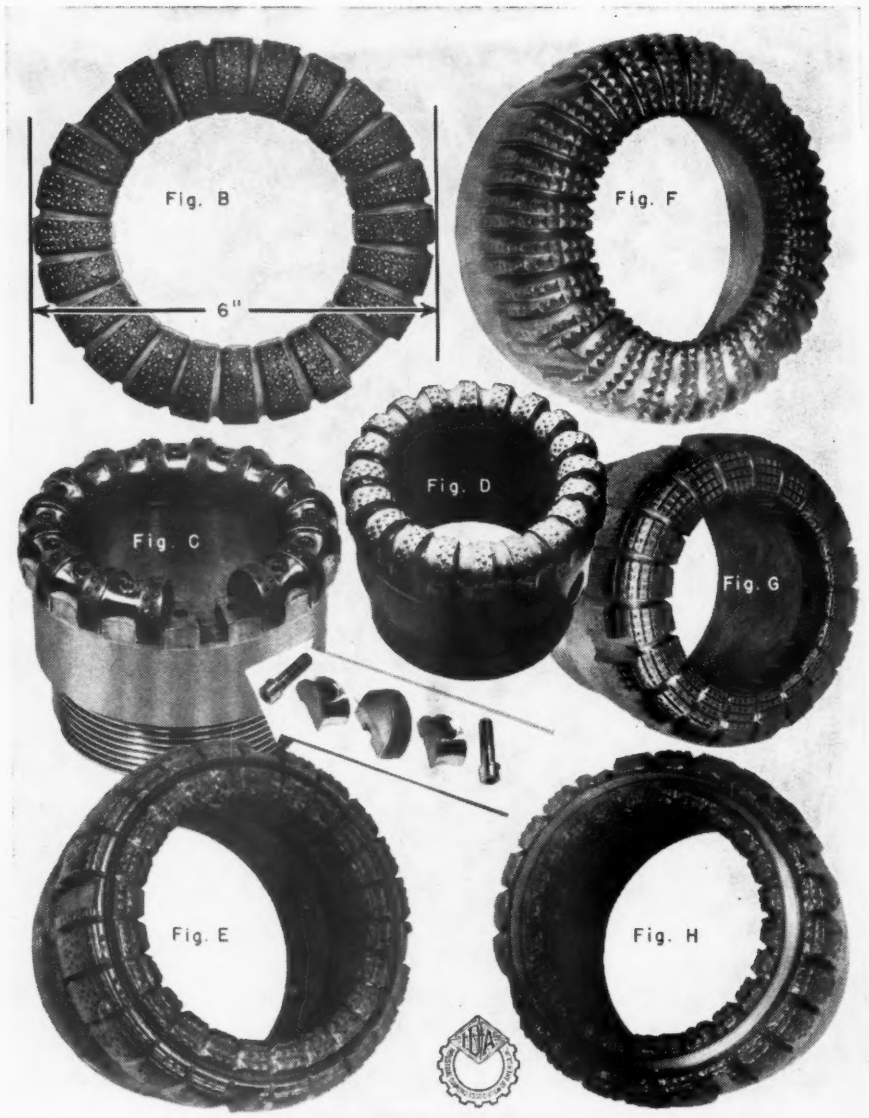

FIG. B. Head of a bit.

FIG. C. Removable insert type bit.

FIG. D. Brazed insert type bit.

FIG. E. Water ways plugged causing burning of diamonds on track—breakdown around center of track.

FIG. F. Pyramid type bit specially designed for shales and softer limestone.

FIG. G. "W" type bit specially designed for hard limestone and chert.

FIG. H. Groove on track caused by junk iron rolling around on face — breaking diamonds — and rapid matrix erosion follows. Also note signs of fluid erosion on inside diameter.

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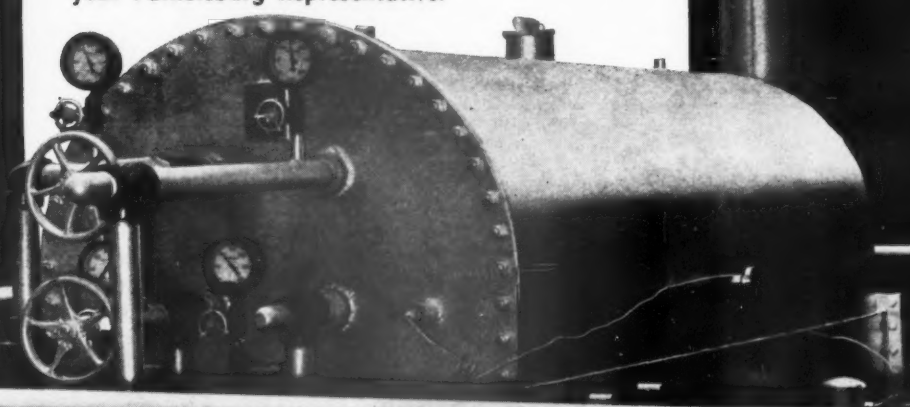

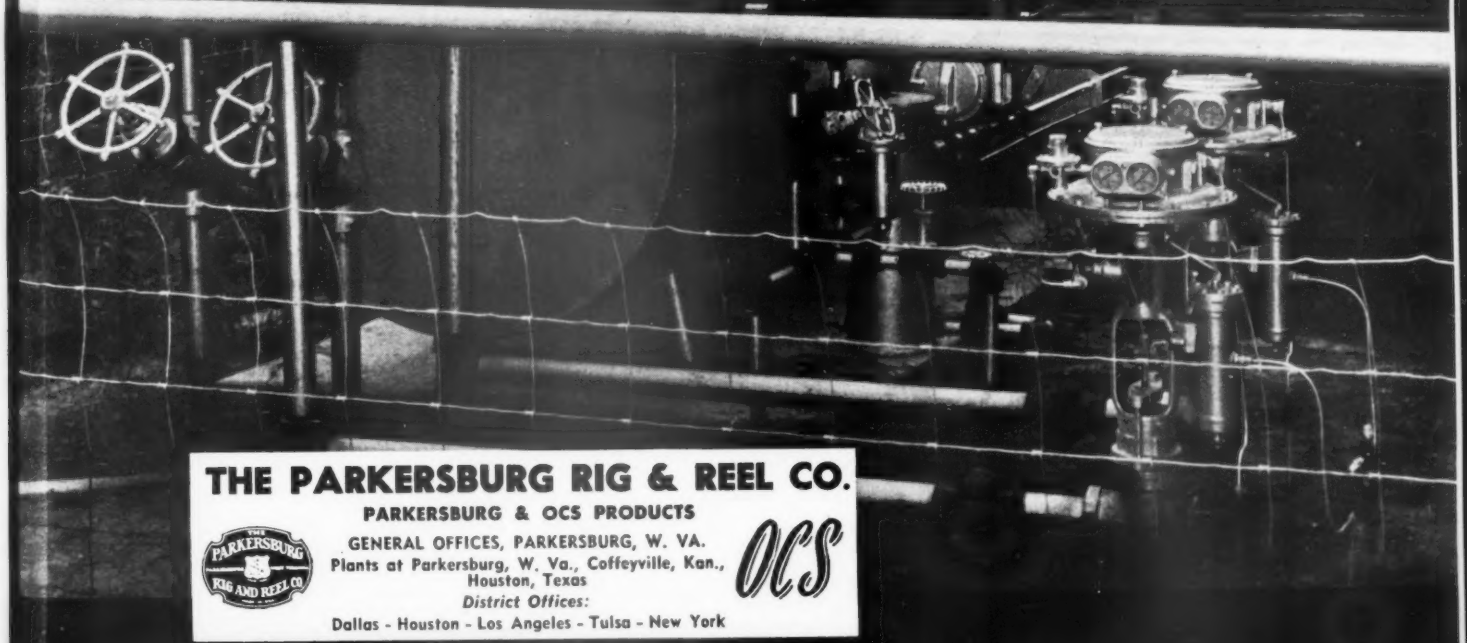

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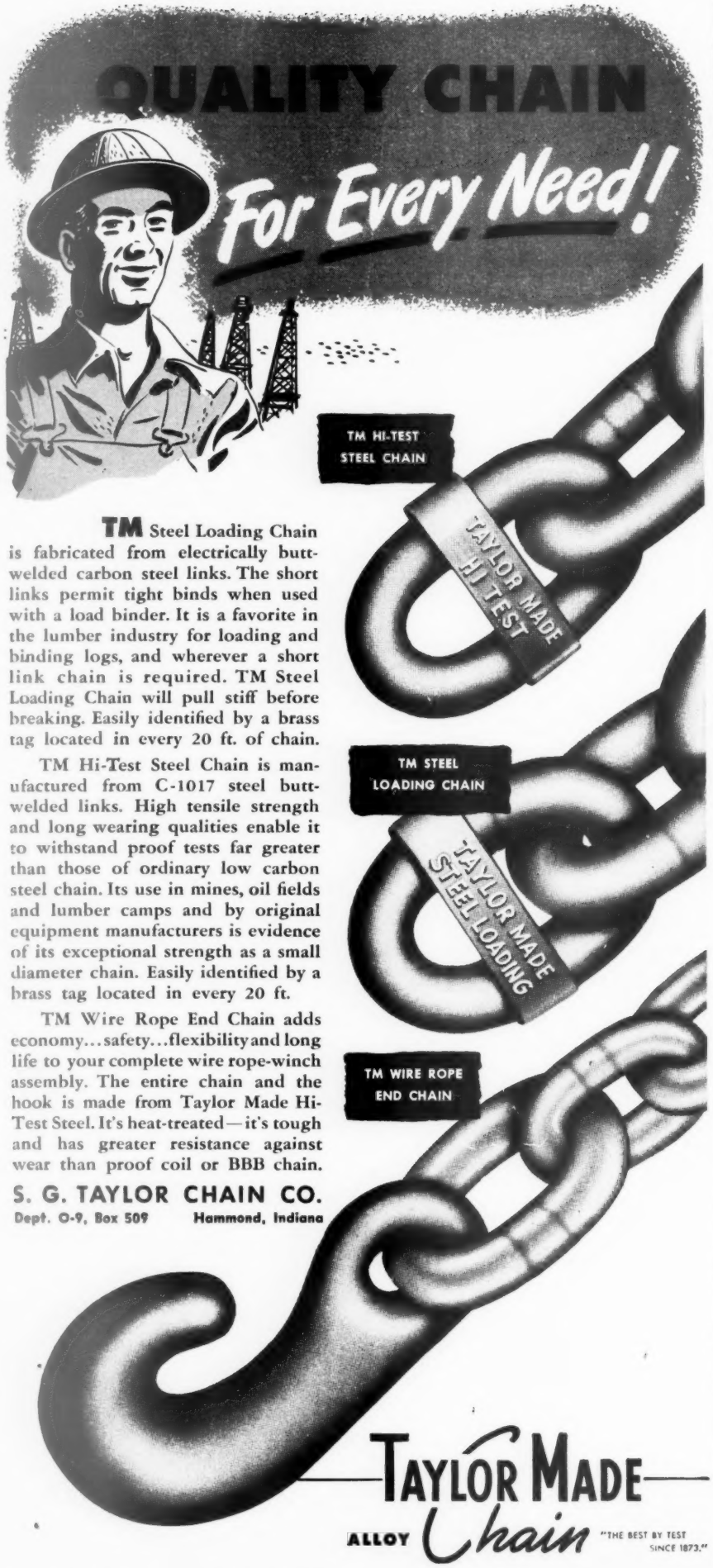

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of diamonds, set in various designs, are necessary in order to obtain the lowest drilling costs. (Figs. B, C, D, F, and G). Diamonds above the range of sizes needed in the mining field are used for this deep hole work, and occasionally carbonados are employed for holding gauge and reaming.

It is fortunate that slow rotational speeds and comparatively heavy weights have permitted the use of diamond sizes that are not particularly suitable for diamond drilling in the mining industry. It is important that future developments do not upset this balance, because the supply situation could be adversely affected if this were not so.

▸ **Diamond salvage and resetting.** When diamond bits are carefully used it is possible to recover a high percentage of the diamonds and reset them in subsequent bits. In calculating bit costs per foot this is an important factor, because diamond bits cost many times more than rock bits, or other drilling tools, and if it were not for the recovery of diamonds there are many instances where the cost would not compare favorably. Furthermore, as the use of diamond bits spreads there will be increasing importance attached to the conservation of valuable mineral.

▸ **Use and care.** *A clean hole.* The use and care of bits in deep drilling therefore resolves itself into a series of interrelated handling and operational techniques. Every effort must be made to see that the hole is clean by removing foreign objects before drilling begins, and measures must also be taken to preclude the possibility of anything falling into the hole during the operation.

Pressure gauge as a safeguard. The mud volume should be the minimum required to keep the hole in condition, and once this has been established the volume must be kept constant by a close check on the mud pumps and continuous observation of the mud pressure gauge. The pressure gauge also serves a most useful purpose in warning the operator when the bit breaks down. As soon as a ring of diamonds has failed the rock formation quickly digs a groove in the matrix metal. In doing so it shuts off the circulation passages across the face of the bit and the fluid pressure rises abruptly. If the bit is picked off bottom at this time, little diamond loss will be sustained; but if drilling is continued the entire bit may be destroyed. Because of the variations in hardness of the rocks being penetrated other indications of bit failure are not always reliable, but a sharp rise in the fluid pressure gauge reading means that the operation should be

stopped and the cause determined. Core blocking on the inside radius of the bit, or thick lumps in the mud itself, will give a pressure increase, and so it is usual to circulate off bottom for a short period and then attempt to resume the drilling operation. If the pressure rises above the established normal, however, when the bit is put on bottom again it is conclusive proof that failure has occurred, and the bit should be brought to the surface without further delay.

Rotational speed related to weight. The best rotational speed for each formation can be established within a short time after beginning to drill. The proper weight is closely related to the rotational speed, and these two factors should be varied together until the most efficient combination is found; after that both should be held within the closest possible limits.

Bringing up the bit for examination. Due to its hardness, a diamond is a positive cutter when subjected to simultaneous thrust and torque, but, being vulnerable to impact and heat, damage can occur very quickly when things go wrong, and this is apparent as soon as the penetration rate slows down or the bit stops cutting. Cores wedging in the core barrel may prevent penetration, in which case it is necessary to bring the barrel to the surface and empty it. If this is not done, all the weight being applied to the bit will actually be imposed upon the bearings of the core barrel inner tube, in which the core is wedging, and they will be damaged. An added danger is that the diamond will drag over the bottom of the hole, instead of penetrating the rock, and sufficient friction will take place to cause burning. (Fig. E). Diamonds last longest when they are steadily at work. When core is not wedging, but passing freely into the barrel, and the penetration rate shows any serious drop, it is an indication that the bit should be brought to the surface for examination.

Care in handling when not in operation. The examination of used bits and care in handling them on the surface also play an important part in drilling economy. Diamonds can even be broken in shipping, unless the bits are adequately packaged, and proper care should always be exercised when handling bits in the field. They invariably should be set down on wood rather than metal, with the diamond surface uppermost. When putting a bit onto a core barrel the threads should first be inspected and then it should be screwed on by hand as far as it will go. Then, when wrenches or power tongs are used, the gripping

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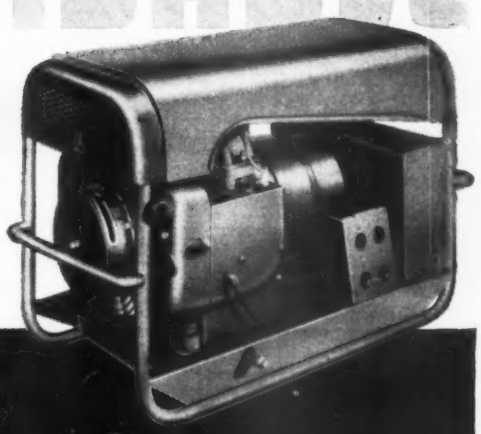

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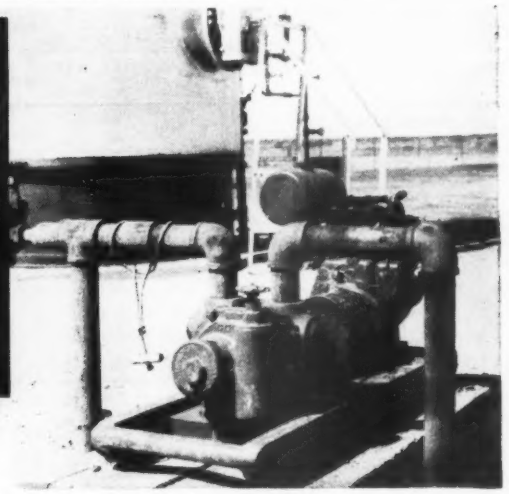

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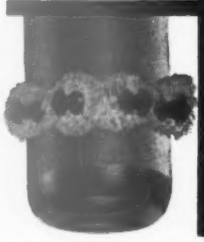

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LATERAL FLOW WHILE CEMENTING

CAMERON - NUWELL FLOAT COLLAR AND SHOE shown in cross-section. Note how the slotted cage in the Float Collar retains the large back-pressure ball, but the smaller diverter ball, shown entering shoe, readily passes thru the Float Collar to seat in the shoe and seal the axial hole.

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Application of pump pressure shatters diaphragm which permits all fluid to flow through side ports.

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surfaces must be kept clear of the diamonds, and torque should be applied to the matrix metal only, or to the steel blank to which the matrix is attached.

Stabilization and straightness of barrel. It is also of importance to make sure that the core barrel is stabilized and has no bends or kinks in it. Otherwise the bit will be thrown to one side when working, which causes uneven wear on the cutting face. Half the normal diamond area will be taking the full weight and doing all the work, which means overloading and consequent reduction of the footage obtainable with the bit. In most cases the wear is not so rapid as might be supposed, and signs of this condition can be observed while still in the early stages. All bits should be carefully examined each time the core barrel is emptied, and when wear is observed on one side only the core barrel should be checked immediately. Correcting the stabilization or straightening the barrel, whichever may be required, will prevent the uneven wear from continuing to a point where the bit becomes seriously damaged.

Precautions when pieces of core are in the hole. When pieces of core are left at the bottom of the hole there is always a grave danger of ruining the inside diameter of the bit upon resuming the drilling operation. When it is suspected that core has been left in the hole the exact position of the old core should be established as nearly as possible, and only light weight and slow rotational speeds should be used when drilling over it. When the core remains upright at the bottom of the hole the bit will frequently slip back over it, and normal drilling can be resumed almost at once, but when the core falls sideways or turns in the hole it will have to be ground up slowly in order to prevent damage to the bit.

In a great many cases a small piece of core is left sticking up from the bottom of the hole, for it is seldom that the core catcher, which is up inside the bit, pulls the core out by the roots. This is an additional reason for beginning each new run gently and slowly, so that the bit has a chance to seat itself over the core nodule and rest firmly on bottom before the drilling operation begins at normal speed. A high percentage of the troubles encountered through left cores can be eliminated if the core catcher is examined each time the core is removed from the barrel. The catcher should fit the core snugly, the inside should show no signs of wear, and it should fit the bevel inside the bit in such a way that it has freedom of vertical movement.

Arresting matrix erosion. Fluid erosion of the matrix, if allowed to continue unchecked, will cause early breakdown of the bit and is usually accompanied by excessive diamond loss. Signs of erosion are easily apparent when examining bits in use, and it is sometimes possible to alter the fluid volume enough to arrest further erosion without affecting the condition of the hole. If this is not possible subsequent bits must have provision made for a greater volume of fluid, but care must be taken in altering the fluid passages, because the tendency then is for most of the fluid to go through the larger passages instead of around the diamonds. This increases the danger of burning; it also prevents the cuttings from being ejected efficiently, which, in turn, decreases both the penetration speed and the life of the bit.

▸ **Conclusion.** Diamond bits in the oil fields have drilled successfully to depths of 17,000 ft, but in all deep drilling the controls are so remote from the working face that every reasonable precaution must be taken to maintain advantageous conditions, and to keep them as constant as possible during the entire operation.

The article has not yet been written that, from its reading, will insure the proper performance of highly technical operations. The Industrial Diamond Association has stressed in all its technical articles, in every field, the utter impossibility of substituting with advice for the intelligent, experienced engineer. When that engineer finds that his experience and technical reading, such as this, do not permit him to overcome certain problems, as all engineers must find at times, he should arrange consultation with the diamond tool engineers, whom each reliable core bit manufacturer holds available for the purpose. ★ ★ ★

Missouri pool found

One of the most interesting discoveries recently is the Fristoe pool in southern Benton County, Missouri. Seven wells have been completed for an estimated production of 100 barrels daily on the pump; also six gas producers have been completed and are shut in awaiting tankage and pipe line connections.

The pool is the result of a lucky venture by William Franklin, one-time educator and now vice president of a refrigeration company in St. Louis. He tested his theory that shallow production could be found in the area and got a good showing at 135 ft and found oil at 243 ft.

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(1) Electric plant

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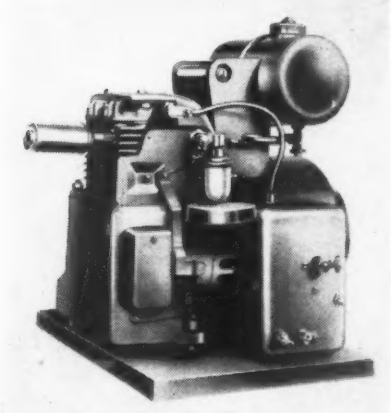
Adding to the appeal of this new, portable Model 03AAE is the unusual feature that permits it to be hooked up to any automobile battery for starting. While the plant is running a special 6-volt winding in the generator charges the starting battery. This a-c model supplies dependable power for standard lights, a-c radios and almost all low-wattage A-C motor-driven appliances. Battery cables, Twistite receptacle for direct plug-in of load, and a high-low toggle switch to regulate the charging rate are standard equipment.



(2) Porcelain valves

Announcement is made by Lapp Insulator Company, Inc., Process Equipment Division, of a new line of armored porcelain valves. In construction, these valves are similar to the widely used Lapp porcelain valves, the innovation being the addition of high-strength, heat-treated silicon aluminum armor.

The body, plug, retaining rings—all parts with which chemicals can come in contact—are of solid, nonporous Lapp porcelain, a material of high corrosion-resistance. The addition of the armor provides protection for personnel and equipment against porcelain breakage from carelessness or accident. Armored valves are recommended by the manufacturer for use in corrosive or contaminating applications.

Armored Y valves are available in 1-in., 1½-in., 2-in., 3-in., 4-in., and 6-in. sizes. Armored angle valves in 1-in. and 2-in. sizes. Armored flush valves in 1½-in., 2-in., and 3-in. sizes for 3-in., 4-in., and 5-in. tank outlets, respectively. Standard 125-lb flanges are integral with armor; porcelain faces are machine ground smooth and flat for gasketing.

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NAME ..... TITLE .....

COMPANY NAME .....

STREET ADDRESS .....

CITY ..... ZONE NO. ..... STATE .....

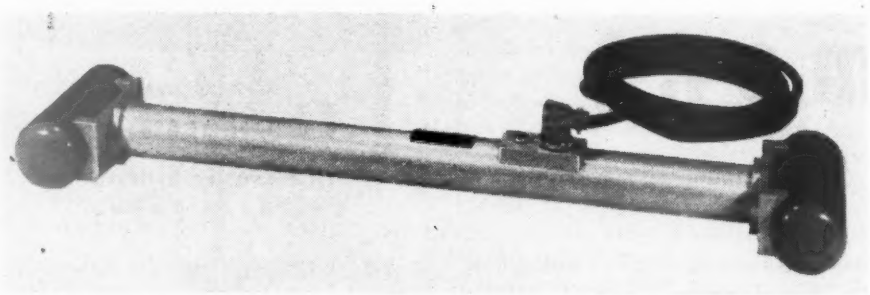
(3) Corrosion measurement

Magnetic forces have been used by engineers in a score of applications from atom splitting to automobile clutches. On the other hand, designers have had to grapple with the ill effects of residual (locked-in) magnetism. This can exist naturally in metals or come about as a result of metalworking operations. It will throw instruments out of kilter, make bearings fail, cause electrical control circuits to misbehave, cause dies and jigs to lose their close tolerance.

A way to detect and measure this residual magnetism is offered by Thomas E. Smith, consulting engineers on special devices for aircraft and product development for industry. Smith's magnetometers will uncover and measure magnetic forces, show where and how much demagnetizing has to be done to neutralize them.

The portable meters come in three models, each adapted for specific job: (1) Materials inspection, to measure the amount of residual magnetism in steel parts or assemblies; (2) precision analysis of magnetic fields in aircraft (these fields can be caused by electrical currents, steel cargoes, or the airframe itself); determination of the amount of magnetic influence where a magnetic compass is installed on a plane or ship.

Essentially, all three models consist of a pickup unit and an indicator. The pickup has a magnetic element that responds to the strength and direction of a magnetic field. The indicator unit amplifies this response and gives a direct reading of the intensity of the field and its direction. The Magnetometers, Smith says, are sensitive enough to pickup magnetic fields that cause a deflection of a half-degree on the compass and sensitivities ranging from 0-30 to 900 milli-gausses. There is also a Gradientometer for measuring the corrosion in pipe lines.



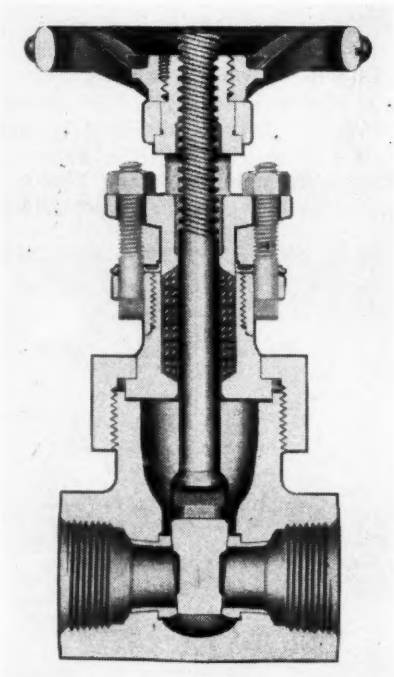
Gradientometer for measuring corrosion in pipes.

(4) 600-psi valves

To meet a demand for small, compact valves in the 600-psi class, Crane Co., has announced a new line of union bonnet 600-psi cast-steel gate valves. The new valves have been designated No. 3602XW and 3602X, and will replace the No. 3606XW and 3606X, which are being discontinued. The new valves are available in sizes ¼ through 2 in., with screwed ends and two kinds of trim. The 3602XW has Exelloy seats and a hardened stainless-steel disc; the 3602X has both seats and disc of Exelloy.

The valves are the union-bonnet type. In sizes ¾ through 2 in. the bonnet ring, bonnet and yoke are separate parts; from ¼ through ½ in. these parts are cast in one piece. The joint between the body and bonnet is sealed with a soft iron gasket, which is not affected by high temperatures or by any of the fluids for which the valve is recommended. The valve has an outside screw and yoke. Special attention has been given to the design of the stuffingbox, which is deep enough on valves over ¾ in. in size to hold six rings of square packing. The gland is held by two T-head bolts fitted into slots in the yoke and can be adjusted easily.

The XW valves are recommended for superheated or saturated steam,



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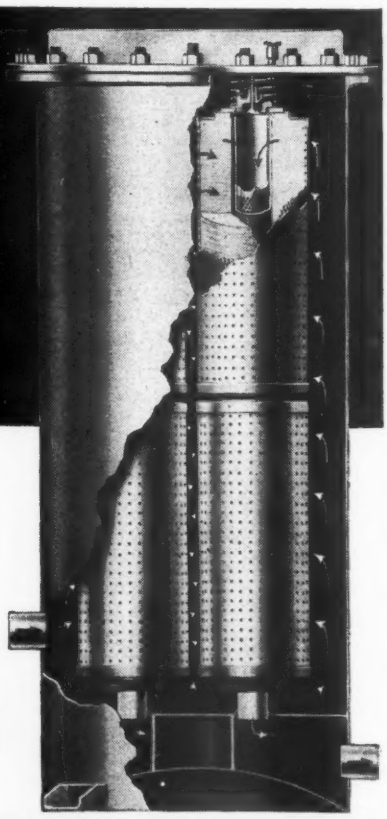

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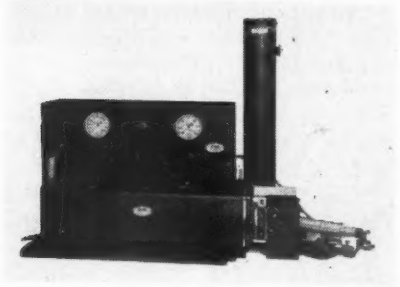
hot or cold water, ordinary air, natural gas, fuel oil, gasoline, low-viscosity oil such as is used in hydraulic systems, butane, propane, and for fluids that are non-lubricating and relatively non-corrosive; top temperature recommendations are 850 F. The X valves are recommended for oil and oil vapor at temperatures up to 1000 F; these valves are not recommended for steam of other non-lubricating fluids, because the Exelloy-to-Exelloy seating faces have a tendency to gall in such service, particularly if the seating loads are unusually high.

The new line of union bonnet valves does not replace Crane 600-psi small steel bolted-bonnet valves, which Crane will continue to manufacture as heretofore.

(5) Flame spectrophotometer

A Beckman Flame Spectrophotometer has recently been announced by National Technical Laboratories, manufacturers of Beckman pH meters, Beckman radiation meters, and other well-known Beckman instruments. The new unit greatly simplifies both qualitative and quantitative analyses of a large number of chemical elements, and its use of a hot flame is of particular value since it permits excitation of the spectral lines of a large number of elements, including many of the heavy metals and alkaline earths, whereas a cool flame instrument excites only those of the alkali metals. Its wide spectral range, covering the ultraviolet, visible and near infrared spectral regions, insures maximum range and versatility.

The method is adaptable to a variety of analytical problems including water analyses, metal and ore analyses, determination of inorganic



traces and impurities in foods, chemicals, biologicals, pharmaceuticals, and in organic materials that can be reduced to inorganic solutions.

Samples are atomized and introduced at a uniform rate into a very hot oxygen and gas flame through a specially designed burner. The spectral emission lines of the elements are excited and the spectrophotometer isolates these lines and measures their intensities relative to a blank or standard.

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...IN BRONZE GATE VALVE DESIGN

LUNKENHEIMER
200 LB. BRONZE *UNION BONNET* GATE VALVE

The new Lunkenheimer 200 Lb. Bronze Union Bonnet Gate Valve incorporates the first application of full cylindrical body sections in bronze gate valves. This construction, previously used only in higher pressure steel valves, provides great strength and maximum resistance against distortion of the valve body and seats due to internal pressure strains and other stresses. Tests made under the most severe conditions prove that this design will not distort and will maintain initial proportions and seat tightness.

In addition to the cylindrical body construction and other service-giving features, these valves employ Lunkenheimer's patented Alloy Stems which eliminate stem thread failure due to wear.

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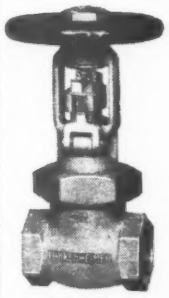
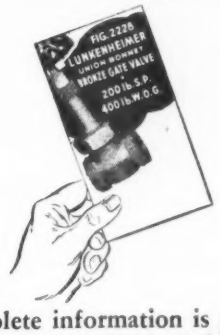
Fig. 2228—Screw Ends
Fig. 2229—Flange Ends
Double Disc, Rising Stem



O. S. & Y. Union Bonnet ¾ to 2 inches
Fig. 2232 — Screw Ends
Fig. 2233 — Flange Ends
Wedge Disc, Rising Stem

Union Bonnet ¼ to 2 inches
Fig. 2230 — Screw Ends
Fig. 2231 — Flange Ends
Wedge Disc, Non-rising Stem



Complete information is given in Circular No. 534. Ask your Lunkenheimer Distributor for a copy or write us direct.

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WECO Steel-Aid . . . contains 67% pure metallic lead and is made specifically for drill collars and tool joints. Metallic Base WECO Steel-Aid will not squeeze out under high torque pressures encountered in these services.

WECO No-Gall . . . contains more than 50% pure metallic zinc, providing operators with a compound that gives tool joint threads maximum protection. Research and actual use have proved WECO No-Gall affords maximum tool joint efficiency.

WECO Hi-Speed Seal . . . a permanent, non-hardening seal universally accepted for casing and tubing threads, steam lines, and oil and gas lines. Hi-Speed Seal is widely used in butane, propane, gasoline and other petroleum services. Unaffected by temperatures to 600° F.

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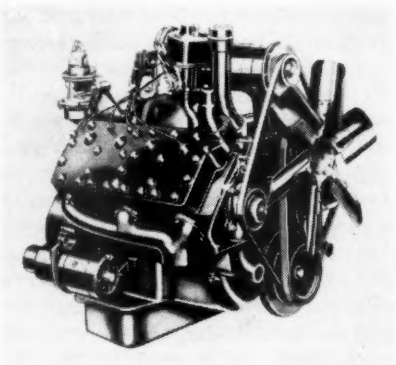
(6) Industrial engines

The Ford Motor Company is in production with five new power plants for the industrial engine field, J. R. Davis, vice president and director of sales and advertising, announces.

Specially engineered for industrial use, these new engines are particularly adapted for the operation of such construction equipment as cranes, shovels, pavers, pumps, winches, hoists, sweepers, oilers, cement mixers, and for other special purposes.

"The new Ford industrial engines are compact, flexible, and durable," Davis declared, "and have exceptional horsepower per pound ratios, an important advantage for power plants in industrial use.

"A principal reason behind the growing demand for Ford industrial engines is the fact that parts and service are available everywhere through more than 6000 Ford dealers. This minimizes time down for repairs, a decided advantage not only in construction but in every industry requiring this type of power plant."



The new Ford industrial engine models are the 337 and 239 V-8's; the 254 and 226 six-cylinder and the 120 four-cylinder. The numerical designation indicates cubic inches of piston displacement in all cases.

Features of all these power plants are intended to assure dependable power, peak performance, long life, and low maintenance costs.

Sales engineers are available for on-the-job assistance in working out unusual applications of industrial power, according to J. F. Bachman, director of the Ford industrial and marine engine department. Power curves and detailed drawings of the new engines are supplied on request, he said.

(7) Pump packing

Ramie, one of the world's oldest vegetable fibers and one that has tantalized textile engineers for more than a century in their efforts to find a practical end use for the material, is now being produced as packing for reciprocating pumps by United States Rubber Company.

Ramie packing is recommended for such uses as cold water and brine pumps because its high tensile strength and ability to absorb and retain lubricants, minimize abrasion, and prolong wear. Its toughness makes it suitable for packing applications where service requirements are too severe for flax or jute fibers, the manufacturer states.

Company engineers have found that Ramie is highly resistant to fresh or salt water, brine or cold oil. Its tensile strength, they point out, is unaffected by moisture and, in fact, increases slightly when wet.

(8) Versatile engine

Newest of the versatile Le Roi company engines is the H-540, a V-8, valve-in-head unit providing extreme flexibility with speeds up to 1800 rpm.

Designed to meet high speed requirements, the new H-540 engine provides smooth power throughout the speed range with conservatively rated horsepowers up to 135.

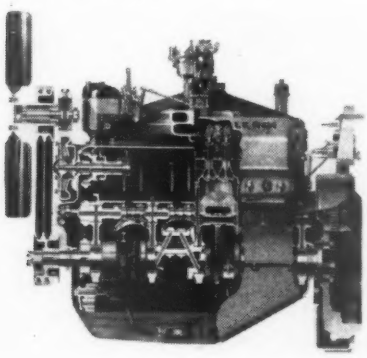
The H-540 is compact, easily accessible, and light in weight despite the horsepower range. It has the strength to withstand the strains of continuous heavy duty service.

The H-540 runs on gasoline, butane, or natural gas, a feature common to all Le Roi engines. This fuel adaptability provides low consumption based on fuel availability, lower operating costs, and trouble free performance, it is asserted.

The valve-in-head design simplifies maintenance by providing greater accessibility. It reduces maintenance costs and fuel consumption, and produces more power.

The H-540 has been thoroughly tested and developed for limitless applications in the industrial, construction, and oil fields.

Features incorporated in the new Le Roi H-540 engine are removable, wet-type cylinder sleeves; extra-heavy, counterweighted crankshaft; unit construction of crankcase and cylinder block; water-cooled manifolds; full-pressure lubrication; gear-driven water pump; modern cam-ground aluminum pistons, and push button electric starting.



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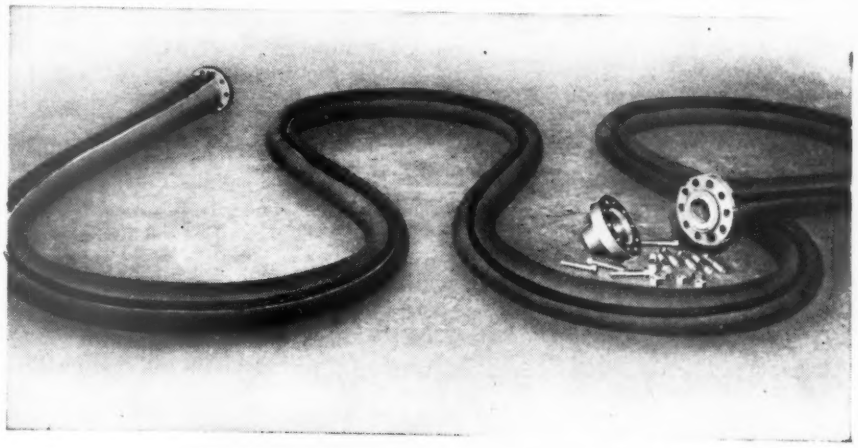

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This fifty-foot length of 3-inch Thermoid* Powerflex Rotary Hose snaked out shows no strain or kink in the hose at any time. Thermoid Powerflex PRESSURE SEAL Rotary Hose can be coiled into smaller diameter without injury than any type of rotary hose — whether light or heavy duty.

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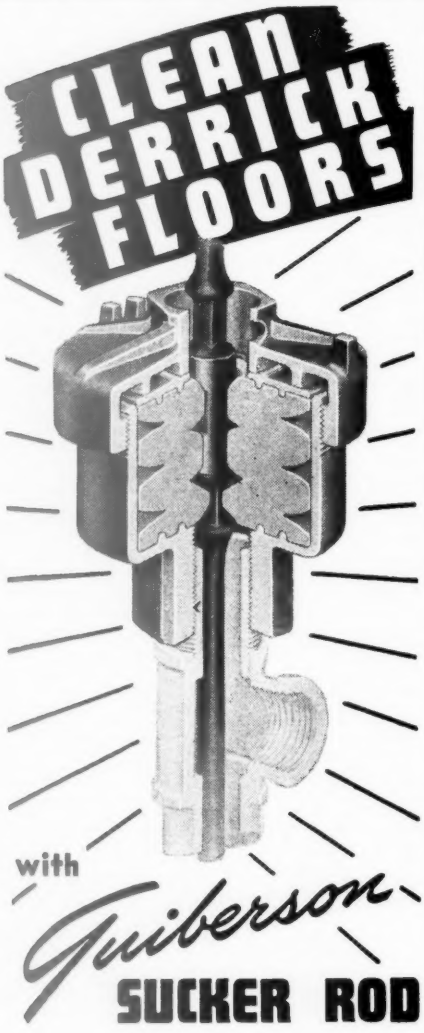

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(9) Short haul carrier

Meeting the demand of utilities, water supply, and pipe line companies, requiring additional telephone facilities, the FTR 9-H-1, a three channel short haul carrier system has been developed by Federal Telephone and Radio Corporation, manufacturing associate of International Telephone and Telegraph Corporation. Through the use of this equipment, three additional telephone circuits can be obtained between field locations and headquarters office at a fraction of the cost of installing new transmission lines.

As a result of the fact that the FTR 9-H-1 was designed for short haul systems, that is from 50 to 150 miles maximum, many equipment economies can be effected without any deterioration in transmission quality characteristics. Hence the cost of the FTR 9-H-1 is so low that it is economically sound to install this system for lines as short as five miles, the manufacturer asserts.

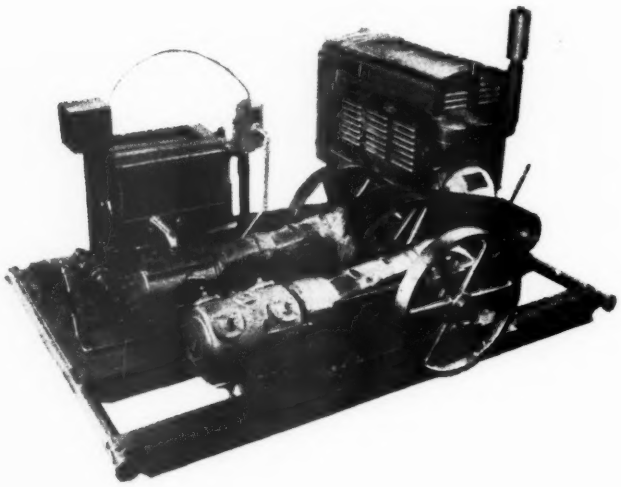
The FTR 9-H-1 carrier system has many unusual features. It occupies only 7 in. of vertical rack space per channel and weighs only 35 lb. The transformers, coils, filters, and capacitors are hermetically sealed—providing long trouble-free life—and mounted on the rear of the panels. The system design is also suitable for operation with radio links and for application with FTR 9-C-1 Speech-Plus-Duplex carrier telegraph equipment wherein two telegraph channels may be added on to each speech channel without loss of the speech facility. Thus it is possible with this equipment plus the FTR 9-C-1 to add three voice and six telegraph channels on existing telephone lines.

(11) Well pumping motor

A three-phase, squirrel-cage, Life-Line induction motor of weatherproof construction is available from Westinghouse Electric Corporation in ratings of ½ to 15 hp (Frames 224 through 326). The motor is of all-steel construction — steel frame, feet and end brackets resulting in a lighter and more compact motor.

The new motor-Type CSP for outdoor oil well pumping service utilizes the self-sealed, prelubricated ball bearings that provide effective lubrication for 5 years or longer without repacking. In addition, time-tested Westinghouse Tuffernell insulation with Tufvar wire provides maximum dielectric strength with high flexibility.

The motors are available for 60-cycle, 3-phase, 220-440 volts (Frames 224-326), 900-1800-rpm, 40 C rise continuous duty open NEMA designs B and C and 50 C rise continuous duty open NEMA design D (5-8 per cent slip). Normal-troque, normal slip: high-torque, normal-slip: high-torque, 5 to 8 per cent slip.



(10) Packaged compressor

Pictured here is a size 8-in. by 4¼-in. by 9-in., class ES-1, packaged portable compressor plant that is filling many needs in the producing industry. These units are assembled in both single-stage and double-stage and are available in various sizes to meet specific requirements. They are mounted on heavy skids and are completely assembled, requiring only connecting the suction and discharge lines to be put in operation. They are easily transportable by truck.

These packaged portable compressors can be used on gathering lines instead of permanent installations, according to the manufacturer. Wilson Supply Company. They are especially adaptable to gas-oil lift and repressuring projects and gas line booster work, it is asserted.

(12) Wireline stuffingbox

The identical Otis wireline stuffingbox (10,000 psi test) heretofore used exclusively by Otis service crews to run and pull sub-surface controls and to perform routine and emergency wireline work, is now available to the industry. Exclusive heavy-duty safety features include a single-piece extra-strong body, an internal blowout preventer plunger that is used also when it becomes necessary to change packing under pressure, a combination gland nut and oil cup that affords a

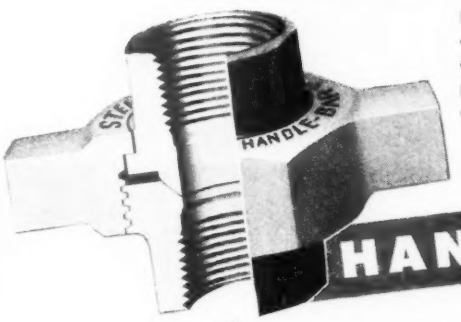
means to tighten the packing and lubricate the line, and a 10-in. sheave that handles heavier lines with less fatigue and breakage. The Otis high pressure wireline stuffingbox can be removed or replaced under pressure.

(13) Portable compressor

The Pac-Air is a recent addition to Ingersoll-Rand's line of portable compressors. It is a self-contained, completely air - cooled, gasoline - engine - driven unit intended for use by small building contractors, plumbing and electrical contractors, cemeteries and

CHOICE IN FORGED STEEL UNIONS

For over 35 years these Unions have given consistent and dependable service in the Oil and Gas industries. Universal acceptance and present demand, which is now greater than ever, make them the number one Unions.



HANDLE-BAR

Sizes ⅜" to 4"

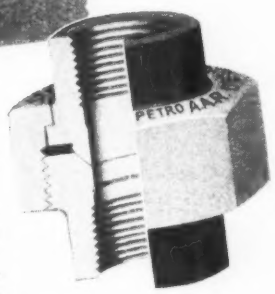
These easy to handle Hi-Speed Handle-Bar Unions have integral steel to steel seats, or completely fused bronze to bronze seats. The nut threads are modified Acme to facilitate easy and speedy assembly and disassembly. The seat design is a 45 degree cone, machined and cold rolled, to a ball seat on the male end. Furnished in black hub ends with Udylited nut, or all rustproof with Udylited hub ends and Parkerized nut.

4000 Test Unions sizes ⅜" to 4" inclusive are furnished with Briggs Standard steam threads in pipe ends.

6000 Test Unions sizes 2" to 4" inclusive have long pipe ends with A.P.I. line pipe threads.

HANDLE-BAR Unions are recommended for all services. Use a hammer instead of a wrench to tighten or loosen the nut.

PETRO

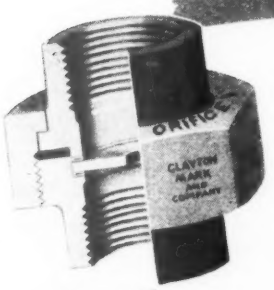


Sizes ⅛" to 3"

This Union has features that make it the most universally used Union. It is made to A.A.R. standards with integral steel to steel seats. The seat design is a 45 degree cone, machined and cold rolled, to a ball seat on the male end. The ends and nut are extra heavy and the nut threads are permanently lubricated and rustproofed with Udylite Cadmium.

A partial list of PETRO'S proven services include pressures from a vacuum to 3000 lbs.; Temperatures from 100° below zero, F., to 1000° above zero F.; on Steam, Gas, Air, Oil, Gasoline, Ammonia, Chemicals, and all other services in which Steel or Wrought Iron Pipe is used.

ORIFICE



Sizes ¼" to 3"

"ORIFICE" Unions, screwed, or socket weld are widely used for flow control of Steam, Oil, Ammonia, Chemicals, Water, Gas and Air. Also for metering and measuring. The ORIFICE is recommended for working pressures of 600 lbs. at 900° F., or 2000 lbs. at 150° F. Furnished with 18-8 stainless steel orifice plate and steel jacketed asbestos filled gaskets. These are set in a groove of solid steel to facilitate ease of tightening and to safeguard against possible blowing of the gaskets and resultant trouble.

The nut threads are Cadmium plated (UDYLITED) for permanent thread lubrication.

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farms, or as a utility compressor for large contractors.

The two cylinder, single-stage compressor has a piston displacement of 37.5 cfm at 80 psi pressure. It is equipped with an automatic unloader which permits the compressor to operate at constant speed, but compress air only when needed. The compressor and its gasoline-engine driver are mounted on an air receiver, which forms an integral part of the running gear. A quick-detachable ball-and-socket type trailer hitch makes the Pac-Air easy to tow behind a truck or passenger vehicle.

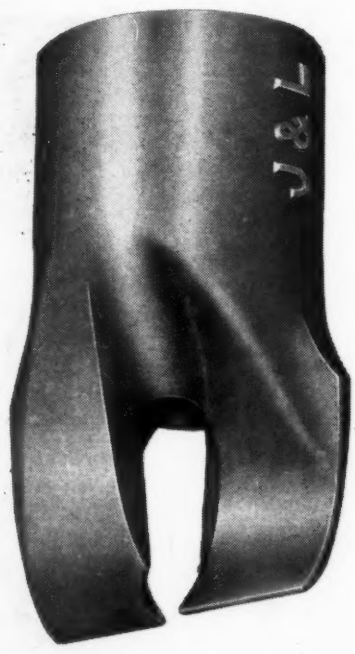
(14) Raman spectroscopy

Complete Raman equipment designed for industrial laboratories is announced by Lane-Wells Company of Pasadena, California. The equipment includes a high-speed Raman spectrograph and powerful Raman excitation equipment. Typical compounds give useful spectrograms with exposure times of about one minute. For example, in 45 sec exposure a 4½-ml isooctane sample yields over 15 usabledensity Raman lines on Tri-X Pan film. Special low-pressure high-current mercury lamps excite well-defined Raman lines, and the spectrograph has excellent definition over the whole 4000-6500 A range. Dispersion provided is exceptional for an f/3 camera, permitting use of fast films without loss of resolution. In addition, coated optics, well-designed baffles, and low-pressure lamps minimize background so that even the weaker Raman lines are detected.

(15) Expendable fishtail bit

Following closely on the introduction of its new integral joint shot hole casing by the Jones and Laughlin Steel Corporation is an announcement by the Jones and Laughlin Supply Company, of the availability of a new expendable fishtail bit designed for use with the casing.

Of particular interest in the design of this bit is the location and size of the watercourse. Note in the accompanying illustration that the watercourse is directed straight down into the formation being drilled. This gives more effective penetration and better cutting action at the blades.



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2–Sucker Rod Guide
3–Traveling Valve Guide
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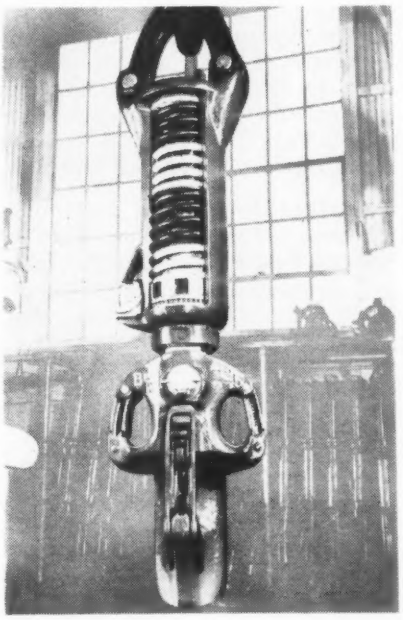
AMERICAN IRON AND MACHINE WORKS CO.
Oklahoma City — Box 1177 — L. D. 518

The new J&L bit and the integral joint shot hole casing make an efficient team for drilling in soft, moist formations where cave-ins and sloughs are encountered or where "jetting" is necessary. Under field conditions of this type, drilling and casing setting are performed in one efficient operation .

(16) Super triplex hook

A special cutaway photo of the housing of a 125-ton Byron Jackson super - triplex hook clearly demonstrates the double spring construction and solid one-piece shank with no load-carrying threads.

These hooks are available in four capacities—60-ton, 125-ton, 200-ton, and 300 - ton. Precision - machined swivel rings (lower one visible in the picture) carry loads evenly and permit



free rotation when the hook is unlocked. The shank has no load-carrying threads. A sub-shank threads into the lower section of the shank. The sub-shank carries only the compression of the low-stressed relief springs.

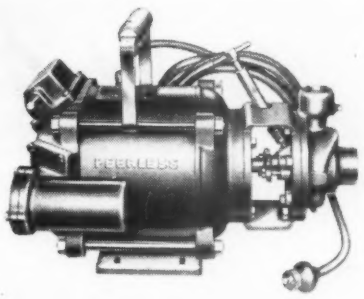
The super-triplex line of hooks feature 6 to 8 in. of spring travel. This assures soft, easy action and eliminates the need for exact spotting of the traveling block. Floating action design means easier handling of drill pipe and less chance of galled pipe threads.

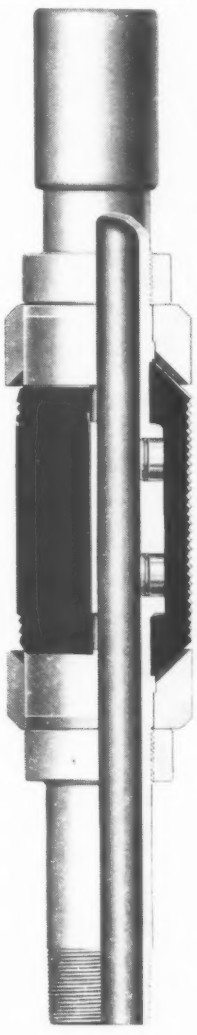
(17) Butane-propane pump

Having a stated capacity of filling a 100-lb cylinder in 6 min, a new, portable, bottle-charging pump for butane-propane service designated as Type MXT, is announced by Peerless Pump Division of the Food Machinery Corporation. The Type MXT is a portable, rugged, complete unibuilt assembly, equipped with a carrying handle and 15 ft of extension cord. Designed for operation on 110 - volt, single phase, 60-cycle house current, it is equipped with an Underwriters' approved ¾-hp explosion-proof electric motor and switch for Class I, Group D applications.

The pump utilizes a vane type impeller, has a rated capacity of 4 gpm at 3500 rpm and develops differential pressures up to 40 psi. Pump discharge has standard 1-in. pipe tap: pump suction has 1¼-in. pipe tap.

For L-P gas services, the Type MXT may be used at bulk plants for transferring liquid from large to small containers, or can be carried on truck for transfer from tank to bottles, at customers' premises.





Type "B" Tubing Anchor

STOP TUBING TRAVEL with the PAGE Tubing Anchor

THE PAGE TYPE "B" Tubing Anchor gives you *six* advantages never before realized in conventional type anchors . . . they're possible because the Page Type "B" incorporates an entirely different operating principle—*it sets hydrostatically and holds hydraulically!*

The Page Type "B" Tubing Anchor permits . . . *(1)—assembly in the tubing string either end up (2)—fast run-in without danger of "accidentally" setting slips (3)—automatic setting without tubing manipulation (4)—setting at correct depths because slips set as fluid rises in tubing (5)—compensation for temperature changes (6)—easy release by simply draining tubing.*

The Type "B" Eliminates...

REVERSE TORQUE on tubing threads—main cause for high pressure leaks.

EXCESSIVE WEAR on casing, tubing and rods—common with compression anchors.

SUCKER ROD BREAKAGE caused by excessive tubing travel. The Page Type "B" Tubing Anchor keeps rod breakage at a minimum because it *smooths out* reversals in the pumping cycle.

Field records prove...

. . . that anchoring the Page Way *increases* pump efficiency and *decreases* equipment wear —visit your nearest D+B Pump Store or Continental Supply Store – find out how Page "Tension Type" Tools can help *you!*

PAGE TENSION TOOLS

PAGE OIL TOOLS, Inc.
3356 Lime Ave., Long Beach 7, Calif.

Mid-Continent Distributors
D+B Division—Emsco Derrick & Equipment Co., Garland, Texas
The Continental Supply Company Dallas, Texas

trade literature

PUBLICATIONS LISTED ARE SENT FREE UPON REQUEST

(18) Catalysts

Product Information Bulletin T-1, which describes catalysts marketed by Enjay Company, Inc., affiliate of Esso Standard Oil Company, is now available. This should be of particular interest to those engaged in hydroforming of naphtha fractions, aromatization, and catalytic reforming.

(19) High pressure industrial pumps

John Bean Division of Food Machinery Corporation has released a new bulletin on its high pressure industrial pumps. Standardized high pressure plunger cup packing type pumps deliver volumes from 2 to 30 gpm with pressures to 800 psi. Capacities of the duplex pumps range from 2 to 6 gpm at pressures from 300 to 400 psi.

(20) Safety and relief valves

Associated Valve and Engineering Company has issued a new bulletin on its line of stainless steel safety and relief valves for the chemical industry. It is stated that the valves are also available in other materials such as monel, aluminum, nickel, hastelloy, etc., on special request.

(21) Instrument panels and cubicles

Falstrom Company has issued a new catalog entitled "Modern Design for Instrument Panels and Cubicles." The catalog is replete with technical information and pictures on the designing of the 1949 style. Of particular interest to many readers will be the knocked-down cubicle because through its flexibility of interchangeable components it serves many purposes in the instrument control field. Single control points can be consolidated into a single compact control center.

(22) Traveling blocks

Just off the press is the new McKissick Products Corporation TB-1949 titled "A Better Traveling Block for Every Purpose." This new bulletin illustrates and describes the family of traveling blocks made by McKissick's. Charts and diagrams give all the information drilling superintendents, purchasing agents, and others connected with buying, want.

(23) 30th anniversay issue

The "30th Anniversary Issue" of *Production Road*, a 40-page magazine published by the Twin Disc Clutch Company, commemorates the company's founding with an informal survey of power and its transmission through the years. Pictures of leading American manufacturers' powered equipment *then* and *now* are featured. "From Adam to Atom," an illustrated essay, traces the history of power transmission from prehistoric times to the present day.

Old turn-of-the-century photographs contrasted with current scenes dramatically portray the development of heavy duty equipment in America. Throughout the magazine's pages are pictures of old and new equipment produced by companies which first used Twin Disc units in the years following World War I and which still use Twin Disc units.

(24) Steam type oil heaters

Lodi steam type oil heaters for the dehydration of wet crudes are fully described in a 4-page color release by Super Mold Corporation. Lower initial cost, lower operating cost, and complete reliability, are claimed for these heating units.

DEAN BROTHERS PUMPS INC. INDEANAPOLIS, INDEANA. PUMPING MACHINERY

ESTABLISHED 1869

DEAN BROTHERS PUMPS INC.

INDIANAPOLIS IND.

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PUMPS

BUILDERS OF OUTSTANDING PUMPS SINCE 1869

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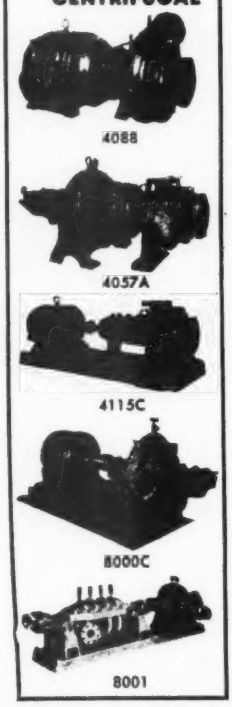
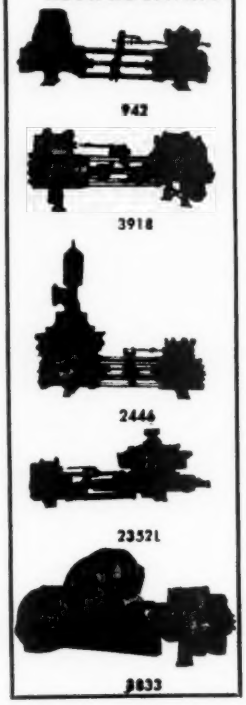


RECIPROCATING



BRANCH OFFICES: NEW YORK HOUSTON

Here's what they're saying about the two HUSKIEST members of

THE SKF FAMILY OF PILLOW BLOCKS

TYPE SAF

Supplied with either self-aligning ball bearing or spherical roller bearing. Equipped with SKF's exclusive Triple-Seal rings. TYPE SA—Same unit with Felt Seals.

JUST THE THING FOR HOISTS, FANS, DRIVES, CONVEYORS, CRUSHERS, PUMPS, COMPRESSORS, HAMMERMILLS, ETC.

"Always get SKF for the TOUGH jobs!" is a byword in mills, mines and factories where these compact, split SAF and SDAF Pillow Blocks and Bearings are now in service.

Consider SKF Pillow Blocks from an engineering point of view: Rugged, easy to install, inspect and lubricate—equipped with SKF's exclusive Triple-Seal rings to keep lubricant *in* . . dust, dirt and water *out!*

On any job—under any load conditions—there is an SKF Pillow Block and Bearing which will make your equipment operate consistently at a lower cost.

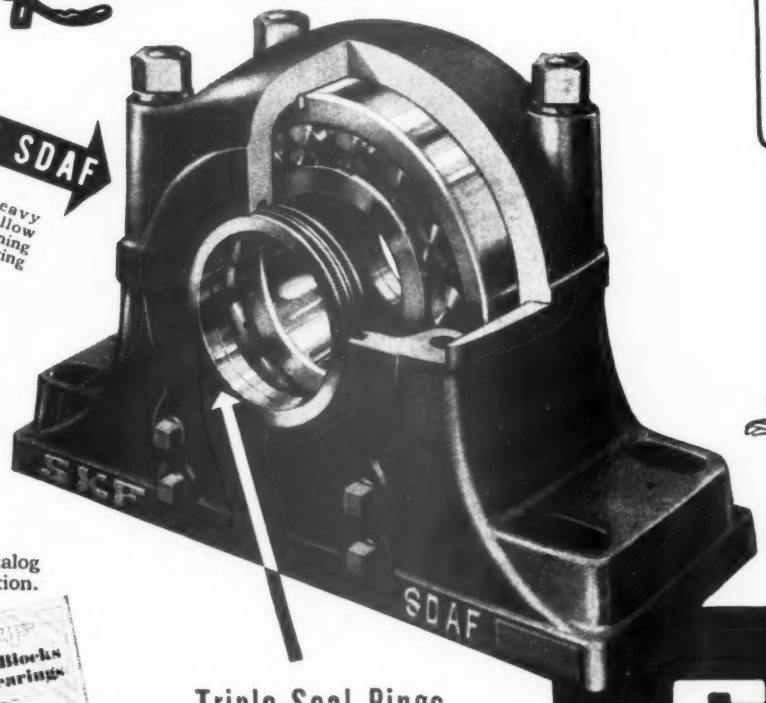
Need some of these husky Pillow Blocks and Bearings? Write us for the name of your nearest stock-carrying Authorized SKF Distributor. 6500

SKF INDUSTRIES, INC., PHILA. 32, PA.

AND HERE'S THE ANSWER FOR HEAVY HAMMERMILLS, PAPER MILLS, STEEL MILLS, OIL FIELDS, ETC.

TYPE SDAF

Exceptionally heavy and rugged pillow block with self-aligning spherical roller bearing for severe loads.



● Send for Catalog 280, second edition.

Triple-Seal Rings

Two split piston rings are located on each side of the bearing assembly. *Inner* rings serve as internal flingers while *outer* rings keep foreign substance from entering the pillow block. Because these rings are not locked to the shaft, they are free to locate themselves whenever shaft expansion occurs.

SKF

PILLOW BLOCKS

They can be steamed up from a cold start to operating pressure in 5 min, it is stated, and are designed to effect heat transfer in the shortest possible time. They are simple to operate and require no electrical facilities whatever, since they perform efficiently and economically on field gas. The only working part is a self-actuating simplex pump, which is mounted out in the open for easy checking, and simplification of such maintenance and repairs as may be necessary.

(25) Bulk Terminal Meter Manual

The Bulk Terminal Meter Manual issued by Ralph N. Brodie Company, Inc., is exactly what it purports to be—a manual—not only on Brodie meters, but on bulk terminal metering generally. It discusses in simplified engineering fashion the varied conditions that may be encountered in a bulk loading plant, and how to choose the best meter or meters for the job that is to be done. It then considers the matters of location, installation, and what auxiliary equipment may be required to give the most accurate and generally satisfactory operation. Efficient and economical operation and maintenance of the metered system is also considered in a logical and orderly manner; and several pages are devoted to methods of calibration. The keeping of meter records, and other incidentals of operation and performance are debated completely, and there is a full treatment of air separators, filters, and other complementary equipment. This brochure, copiously illustrated and meticulously prepared, may well become an industry textbook on the subject of bulk terminal metering.

(26) Steam-detergent cleaning methods

How clean-up routines are being simplified, equipment downtime reduced, costs lowered and many man-hours saved through the use of steam-detergent cleaning methods, is discussed in a special feature article appearing in a recent issue of *Oakite News Service*, house publication of Oakite Products, Inc. The article defines steam-detergent cleaning as the simultaneous application of heat, steam pressure, and detergent solution—a threefold combination so effective that scarcely a soil will stand up against it—that makes possible important time, cost, and work savings. Also emphasized is the ease with which the steam-detergent method may be set up: In addition to a solution-lifting steam gun, the only requisites are a convenient source of steam supply, solution and steam hose, and a suitable container to hold the detergent solution. No pumps, motors, pressure tanks, etc., are necessary, the article states.

(27) Drill pipe and tool joints

A new 12-page bulletin, No. 356, has been issued to describe and illustrate Spang-Chalfant's new Double Seal shrink thread drill pipe and tool joints. The bulletin features the new design, having seals at both the internal and external ends of the pipe threads, as well as the shrink thread design. Methods of replacing tool joints are illustrated, and recommendations for the use and care of drill pipe and tool joints are included. Specifications are given.

(28) Three new bulletins

Three new bulletins, released by Cummins Engine Company, Inc., describe the design, performance and facilities for servicing Cummins diesel engines.

"The Exclusive Cummins Fuel System" is a non-technical description of the system of fuel delivery and injection used in Cummins diesel engines. It compares fuel systems in common use in diesel engines, points out how the exclusive Cummins fuel system differs from other systems, and lists the advantages of the Cummins system in terms of engine performance. The bulletin number is 5275.

"On-the-job Performance" describes the application of

You can do *yourself*
a world of good
on October 14th*

*Oil
Progress
Day

NOW IS THE TIME TO PREPARE!

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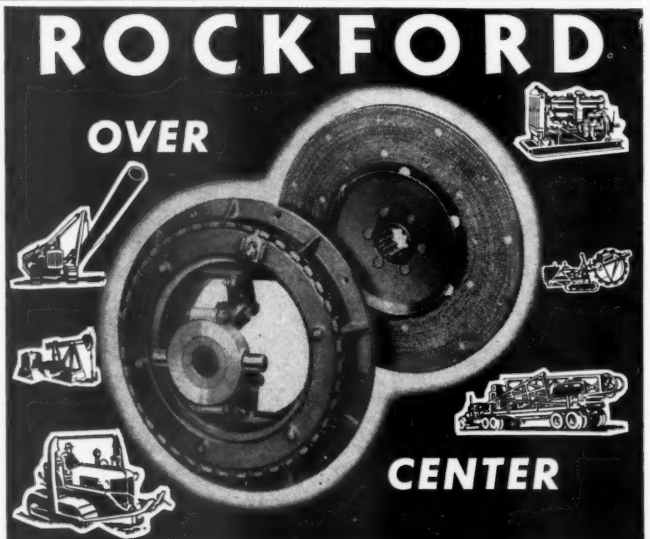
OVER

CENTER
CLUTCHES

EASY OPERATION
HIGH TORQUE
POSITIVE ENGAGEMENT
LARGE DRIVING AREA *
SMOOTH RUNNING
INFREQUENT ADJUSTMENT
MINIMUM INERTIA

* The pressure plates in ROCKFORD Over-Center CLUTCHES have large area, accurately flat-ground surfaces for maximum contact with the facing material. Special alloy iron is used to withstand shock and heat strains. Provision is made for multiple driving, from the back plate. Have hardened steel bearing inserts, where the roller cams operate.

Send for This Handy Bulletin

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications.

Furnishes capacity tables, dimensions and complete specifications.

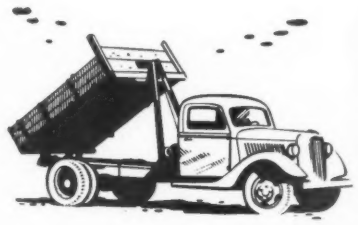
ROCKFORD CLUTCH DIVISION BORG-WARNER
1303 Eighteenth Avenue, Rockford, Illinois, U.S.A.

IT'S A CINCH

WITH TULSA WINCH!

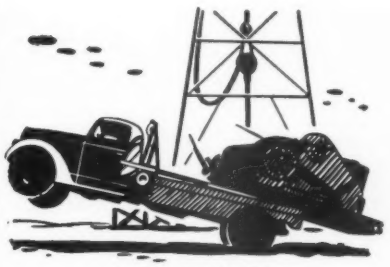
Yes, the job's a cinch with Tulsa Winch, whether it's a load to lift, skid, pull, dump; a tree to uproot or materials to transport. You'll find a hundred-and-one more uses for your truck, too, when you have a powerful Tulsa Winch. Handles loads from 500 pounds to 200,000 pounds.

Tulsa Winch, America's best winch buy, is safety-insurance, too. For Tulsa Winch HOLDS THE LOAD! The exclusive back-off brake is positive protection against costly accidents. Your jobs will be easier, your truck worth more to you, when you have a Tulsa Winch installed. Write for bulletin, and list of distributors. Tulsa Winch Division of Vickers, Inc., 815 E. First, Tulsa, Oklahoma.



DUMPING

PULLING



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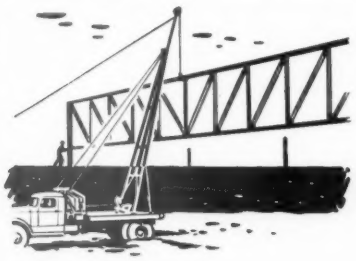

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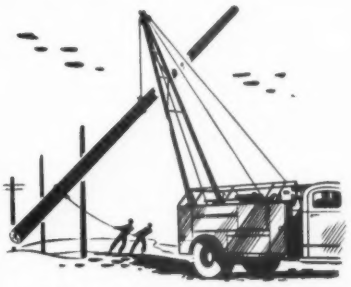
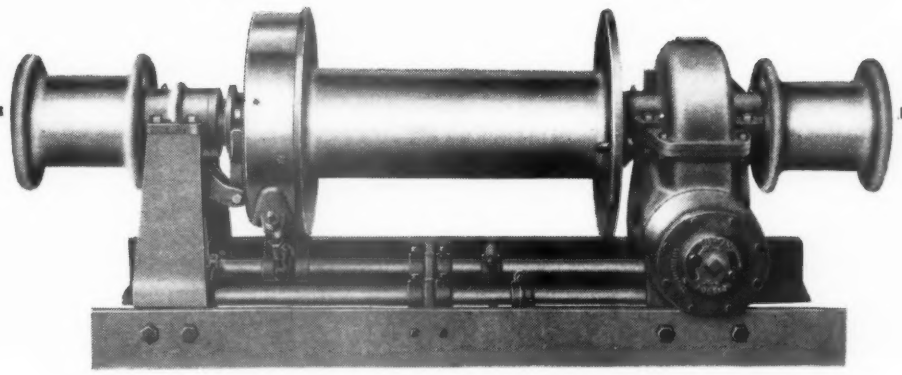


MAINTENANCE



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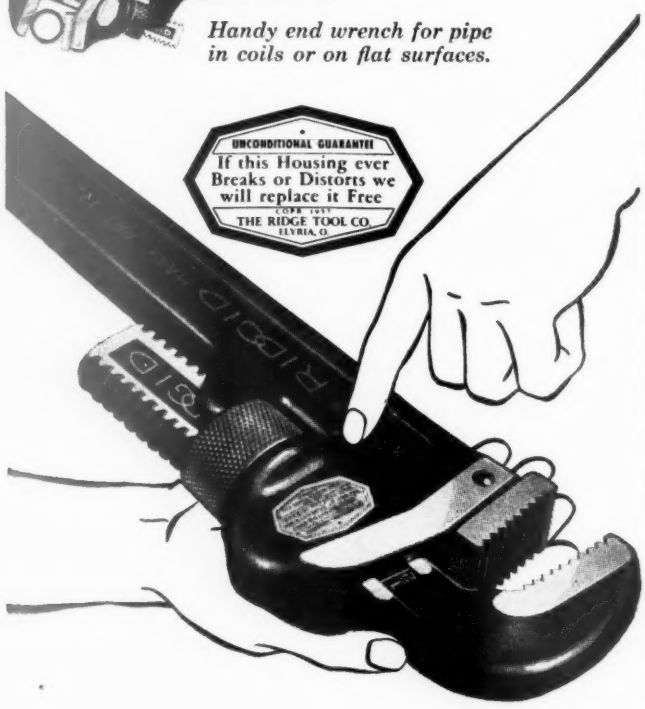
Say goodbye
TO PIPE WRENCH TROUBLES

RIDGID guarantee means no wrench housing repair cost—at all—ever!

● RIDGID's unconditional guarantee protects you forever from wrench housing expense and bother. And that's not all. The powerful I-beam handle, instant action non-slip jaws, handy pipe scale on hookjaw and free spinning adjusting nut *all* make for faster, easier work . . . saving both effort and time. Millions of enthusiastic users specify RIDGID wrenches. You'll prefer them, too. Sizes from 6" to 60" available at your Supply House.

Handy end wrench for pipe in coils or on flat surfaces.


UNCONDITIONAL GUARANTEE
If this Housing ever Breaks or Distorts we will replace it Free
THE RIDGE TOOL CO.
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RIDGID
WORK-SAVER PIPE TOOLS
THE RIDGE TOOL COMPANY • ELYRIA, OHIO

Cummins dependable diesels to trucks, shovels, earthmovers, and other equipment used in the construction and material handling industries. This bulletin contains numerous photographs and job histories of Cummins-powered equipment operated by leading contractors throughout the United States. The bulletin number is 5276.

"Dependable Service for Dependable Diesels" is a large wall map showing the location of Cummins sales, service, and parts facilities throughout the world. The bulletin lists the address, telephone number, and service personnel of each of the more than 200 authorized sources of Cummins service. The bulletin number is 6202-3.

(29) Schlumberger catalog available

Schlumberger Well Surveying Corporation has recently published a new catalog that presents illustrations and descriptive data on all 17 Schlumberger services available.

(30) Leak detector

A pamphlet issued by Consolidated Engineering Corporation, provides pertinent details of this company's interesting leak detector. This device is essentially a portable mass spectrometer, which, with the aid of helium, can measure leakage rates lower than 10 cc per sec. in any system or vessel that can be put under low pressure or vacuum The detector is extremely sensitive, and has been used successfully in refineries, for example, to test various plant-scale equipment from small diameter tubing to large tanks and bubble columns.

(31) Slush pump parts

A new 24-page National Supply bulletin, No. 357, describes and illustrates Ideal fluid end parts for slush pumps. It includes Type "GT" piston rods and pistons, Type "G" valves and seats, "Nationaloy" cylinder liners, and liner rubber sleeves. Features and advantages of each part, and specifications are presented. In addition the bulletin tells how to install and get maximum service from parts. Reasons for long service of Ideal valves are demonstrated.

(32) Tube expanders

A new 4-color bulletin that describes Airetool tube expanders for expanding and rolling boiler and heat exchanger tubes is now available upon request.

(33) Industrial water treatment

A new booklet describing industrial water treatment problems and modern methods of solving them is now available from The Bird-Archer Company. The booklet, of particular interest to plant engineers, plant managers, and executives, is attractively printed in two colors and generously illustrated with pertinent photographs and charts. The text covers the broad subject of industrial water treatment from simple, basic theory for the layman to specific problems involved in the use of water for power, process, and cooling.

The complete Bird-Archer 8-point treatment system is described in full detail, and a question and answer section demonstrates how this elastic program can fit any particular requirement.

(34) Tubing safety valves

A new 6-page folder (Bulletin 48-104) describing Otis removable tubing safety valves and removable input tubing safety valves has been published by Otis Pressure Control, Inc. The bulletin carries a complete description of the safety valve automatic mechanism, method of installation, complete parts lists, and engineering data.

(35) Properties of Fairprene

Properties and uses of Fairprene synthetic elastic compositions are described in a 12-page manual, released by the Fabrics Division, E. I. du Pont de Nemours and Company, Inc. The Fairprene products comprise three groups: Sheet stocks without fabric back or cloth insert, coated fabrics, and cements made with synthetic elastomers.

The booklet reviews the physical and chemical charac-

teristics of each of the three groups of Fairprene products. Typical applications of Fairprene are illustrated by photographs. Charts, graphs, and tables present technical data that can be quickly grasped and correlated to individual requirements.

Fairprene coated fabrics are widely used for diaphragms, gaskets, valve cups for oil well pumps, and in a variety of chemical equipment. They are popular because they resist deterioration by oil and greases, gasoline, kerosine, fresh and salt water, as well as alcohol solvents and other chemicals, the manufacturer states. A guide to the selection of the proper type of Fairprene fabric for each special use is a feature of the booklet.

(36) Heat exchangers and vapor condensers

SK heat exchangers and vapor condensers are described in this new bulletin issued by Schutte and Koerting Company. Twelve pages of text, photographs, and sectional drawings present comprehensive data on SK single and two-pass heat exchangers, vapor condensers, U-tube and tank type exchangers, Radiafin tube exchangers, and vent condensers.

Colored cross-section drawings show the methods of operation, and dimension drawings and tables give the overall sizes of the various types.

(37) Water demineralizers

The 26-page booklet, "Filt-R-Stil Demineralizers Deliver Low-Cost Chemical Equivalent of Distilled Water," has been reissued in a revised edition by American Cyanamid Company. This two-color, profusely illustrated booklet, first issued about a year ago, cites the advantages of demineralized water over distilled water, describes briefly the chemical and mechanical principles of demineralization by ion exchange, and gives data on calculating costs for demineralizing various raw waters. In this revised edition, the pages devoted to cataloging the standard demineralizers offered by the company have been revised to include the latest changes in specifications, models available, and performance data for each of the units.

(38) Automatic boiler

A complete description of automatic boilers, ranging from 3 to 350 hp, is to be found in a recent presentation by the Steamaster Automatic Boiler Company. The 4-page illustrated pamphlet gives the specifications of the full line of boilers, including a model that is designed in 10 and 15 hp size for the exclusive use of gas fuel, and series ranging from 3 to 350 hp that can burn gas, oil, coal, or any combination of these. It is especially emphasized that these boilers are shipped with full boiler trim, fully automatic burners for any type of fuel, complete return to boiler system and full electric control panel, completely wired, so that when you have bought a Steamaster, you have an entire unit—with no extras to buy.

(39) Meters for petroleum products

A brochure of keen interest to measurement engineers, and about as complete as brochures come, is that put out by the Granberg Corporation on the Granco line meters. Included in this comprehensive treatment are truck and line meters of great variety, with complete specifications, and intimate details of design, installation, operation, and care. Also described is a line of meters with fully automatic temperature compensation, that can handle all petroleum commodities. It is said to be sensitive to very small fractional temperature fluctuations, and will accurately measure liquids from 15 to 90-deg API gravity. This instrument is ordinarily factory set for a specific liquid, but can be reset in the field to adjust for any change in expansion coefficient. The book further catalogs many meter accessories, and gives full instructions concerning the installation and servicing of all instruments.

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LADISH

Controlled Quality

FORGED STEEL FITTINGS

Many costly shutdowns are prevented by using Ladish fittings because forging under rigid laboratory controls improves physical properties four ways:

1. Increases dynamic strength for greater resistance to hydraulic shock pressures.
2. Produces maximum toughness to withstand prolonged fatigue stresses from vibration.
3. Controls grain flow for better protection against expansion and contraction at temperature extremes.
4. Refines grain structure to retard both erosion and corrosion.

Ample stocks . . . complete line . . . size range ⅛ through 4 inches . . . 2000 through 6000 pound ratings . . . Carbon, Alloy and Stainless steels.

Write for Catalog Vol. 2, Today

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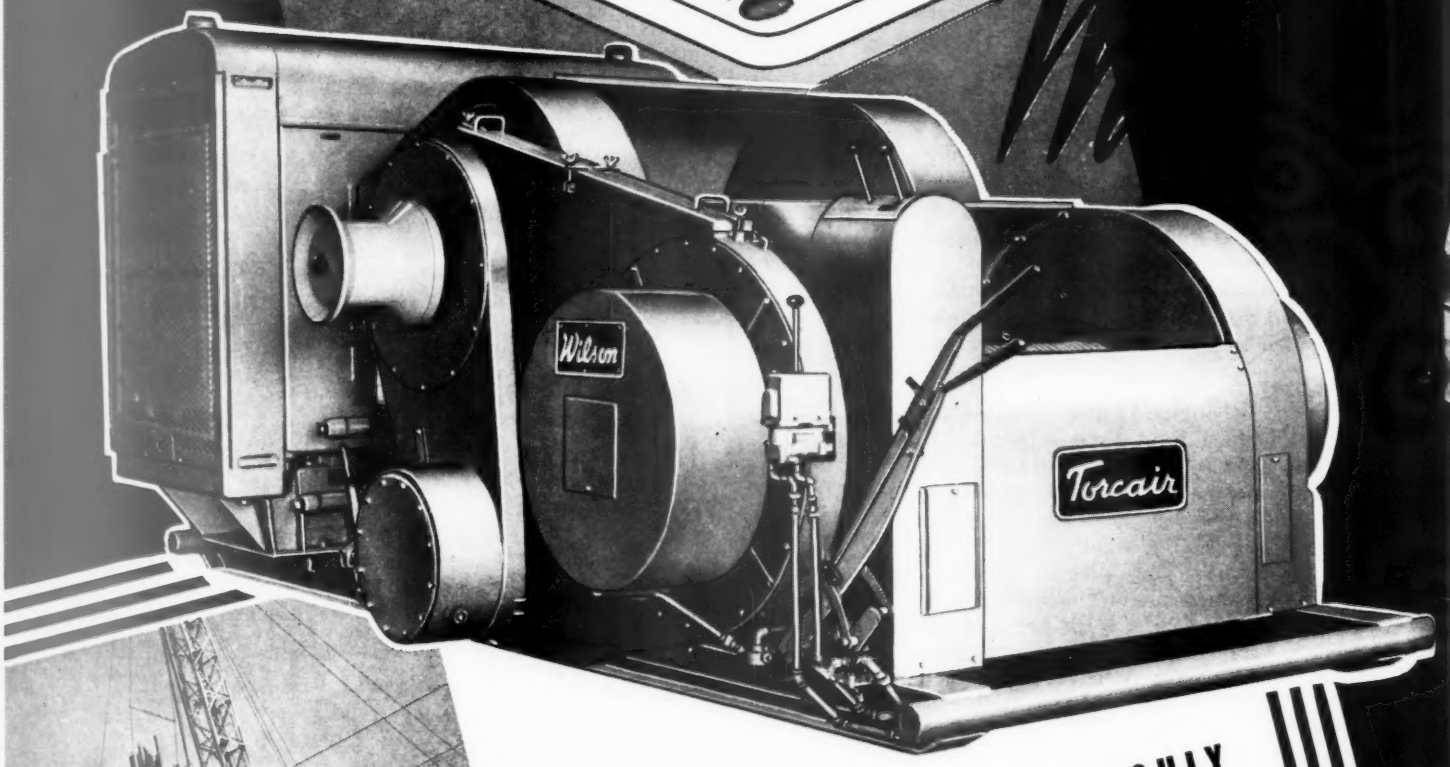
Wilson Torcair



DESIGNED TO PROVIDE A HIGHLY FLEXIBLE CONTROL USING TORQUE CONVERTER DRIVE and AIR CLUTCHES

The Wilson TORCAIR Winch is probably the most modern and highly refined winch on the market today. Available in two sizes . . . the SUPER, recommended for wells up to 6,000′ with 2½″ tubing, and the MOGUL, without the hydromatic brake recommended for wells up to 8,000′ with 2½″ tubing, and for wells up to 16,000′ with 2½″ tubing when equipped with 15″ double rotor hydromatic brake and engines of suitable power. Both models are made in single or double drum type, and all winches are equipped with Wilson Air-Tube Disc Clutches on both drums with high and low speeds on main drum and one friction clutch speed on the upper or sand line drum. Available with 90′ or 96′ Mast and trailer mounted as shown. The last word in deep well servicing units. WRITE FOR BULLETIN GIVING COMPLETE DETAILS AND SPECIFICATIONS.

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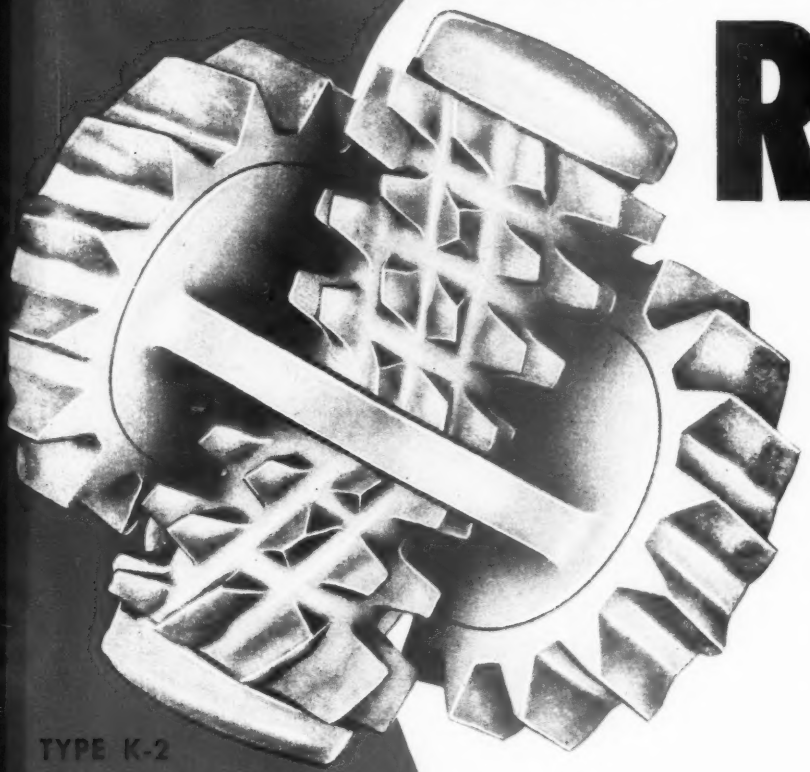
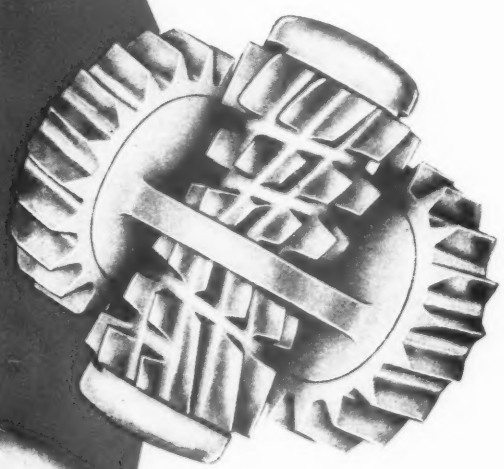
H C Smith

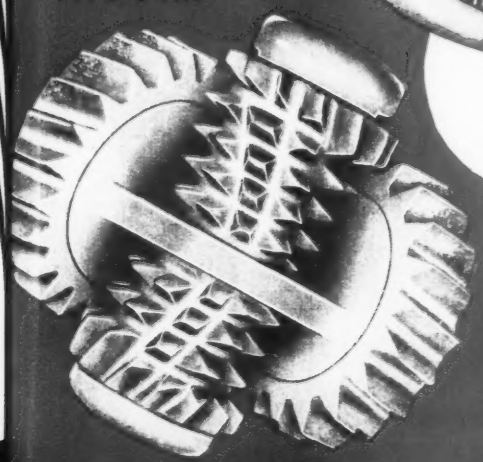
ROCK BITS



TYPE K-2



TYPE C-2C



TYPE 6-HH

There are 10 types of H.C. Smith Rock Bits — each with specially designed teeth to drill specific formations.

You get *faster, straighter, full gauge hole* by choosing the H.C. Smith Rock Bit with the right tooth design for the formation encountered.

H C Smith Oil Tool Co.

GENERAL OFFICES AND PLANT: P.O. BOX 431, COMPTON, CALIF.

Visits Venezuela

W. H. Davison, president of Core Laboratories, Inc., returned recently from a trip to Eastern and Western Venezuela. Davison participated as a member of the Chicago and Southern's inaugural flight from Houston to Caracas, S. A., with other dignitaries from various branches of the petroleum industry.

W. H. Davison

During his visit to Venezuela, he made a detailed survey of core analysis and petroleum reservoir engineering methods and techniques as practiced in that country. Davison stated that he was well received in all active drilling and exploration areas by administrative and engineering personnel who expressed a keen interest in the possibility that Core Lab equipment, personnel, and service might be available to their operations in the near future. He also indicated that, with the establishment of regular passenger and freight flights directly to and from operating areas in Venezuela, the practice of quick-freezing cores in South America for subsequent analysis in the United States was being given serious consideration.

New office

The Vernon Tool Company, Ltd., has announced the opening of a new office at 6226 Washington Avenue. Houston, Texas. This office will supply a complete stock of parts as well as service facilities for Vernon-Corwin desanders, McNeely vibrating screens, Vernon centrifugal pumps, and other Vernon products to users in Texas and the Gulf area.

Vernon also announces that Mud Products, Inc., Tulsa, Oklahoma, has been appointed exclusive distributor for Vernon products in Oklahoma and Kansas.

J. M. Bradley promoted

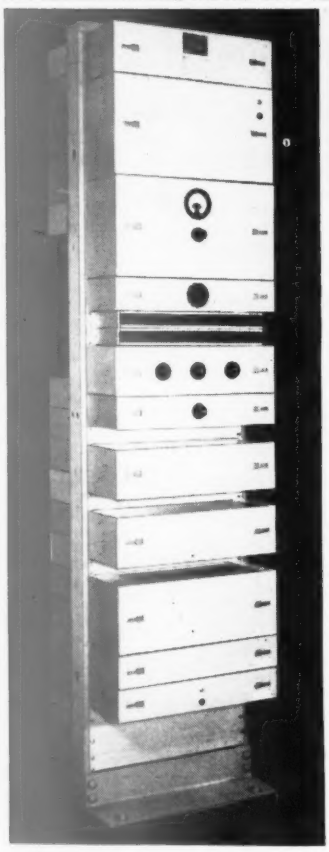
The appointment of James M. Bradley, assistant manager of the Northern Division of Interstate Oil Pipe Line Company, as technical assistant to the president has been announced by Loren F. Kahle, president of Interstate. A veteran of 26 years' pipe line experience, Bradley joined Interstate in December, 1945, as assistant manager of the Northern Division.

Prior to joining Interstate, Bradley served with the Oklahoma Pipe Line Company from 1922 until 1936. In the latter year he resigned to take a position with the Standard Oil Company of Venezuela and remained in South America until 1941, when he accepted the position of Eastern Division superintendent of the Plantation Pipe Line Company. This is the position he held when employed by Interstate.

Appointed by Worthington

Frank J. Whelan, vice president, Worthington Pump and Machinery Corporation, announces the appointment of Frederick J. Ellis as assistant merchandising manager, pumps and compressor sales. Formerly assistant manager of reciprocating pumps sales division, Ellis will head up distribution of standard pumps and compressors through oil field distributors. Ellis joined Worthington in 1916 and served successively in Worthington's offices in Washington, D. C., Denver, Colorado, Detroit, Michigan, Cincinnati, Ohio, Holyoke (Mass.) Works, and Harrison (N. J.) Works. He is president of Worthington's Quarter-Century Club.

F. J. Ellis



MOST EFFICIENT SPECTRUM USE—with Lenkurt 32 Three-Channel Augmented Carrier

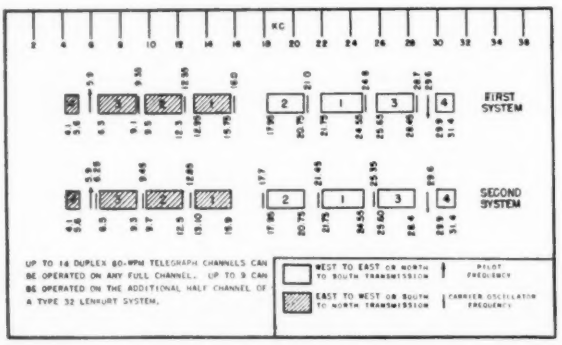
THE NEW LENKURT 32 Carrier provides for maximum utilization of spectrum. Conventional 30-kc system is augmented with space for narrow-band voice circuit or 9 sub-channels for specially-designed telegraph system.

Other advantages of the Lenkurt Augmented 32 Carrier:

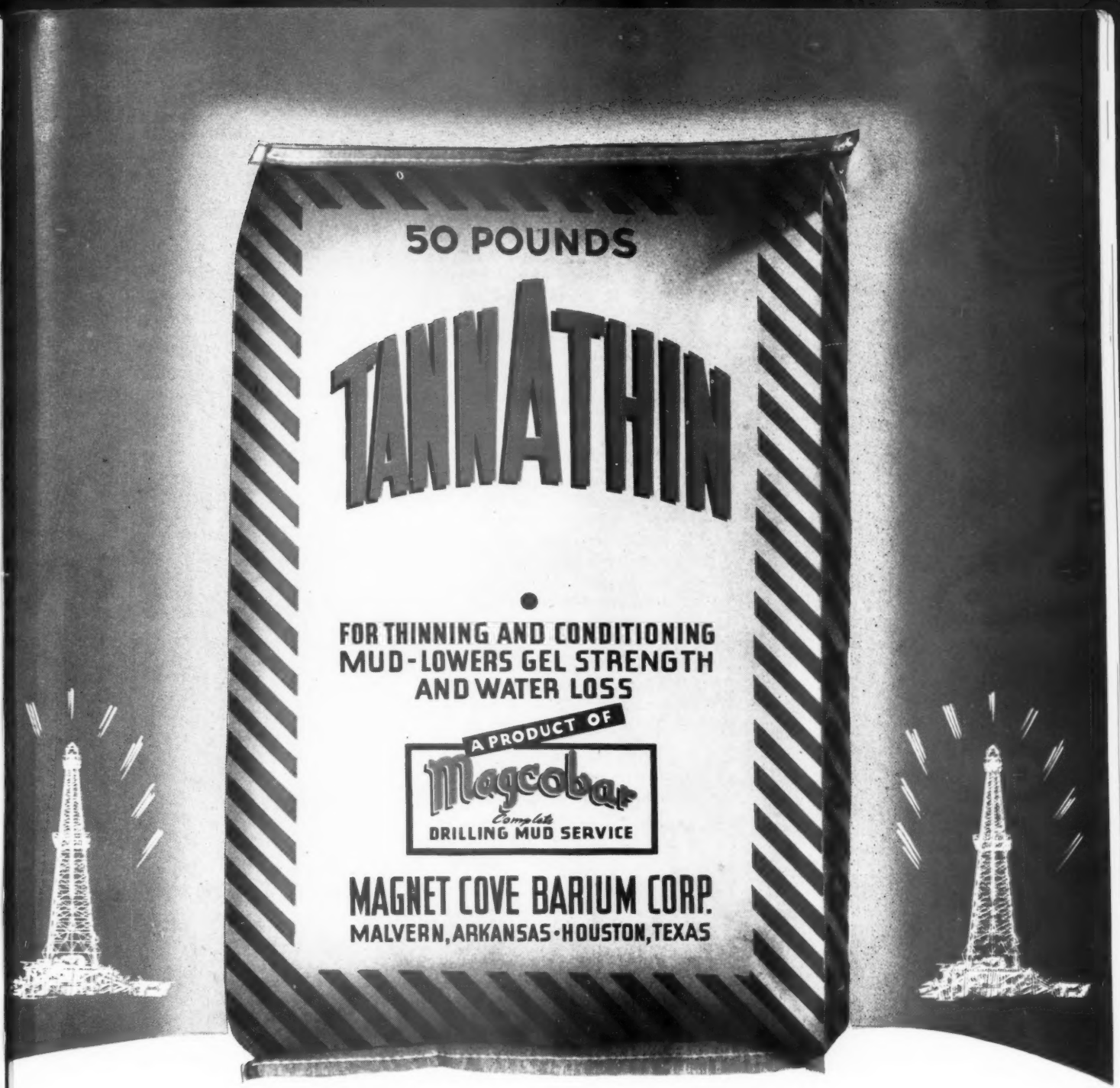
- All-electronic pilot regulation with no contacts, motors, relays, selsyns, or moving parts.
- F-M telegraph with automatic synchronization combines operating margin with stability as good as best physical circuit. Lightning proof!
- Up-to-date design, full toll standards, proved performance, tailor-made components, choice of signaling systems, and rapid delivery.

Lenkurt

KNOWS HOW


KC
FIRST SYSTEM
SECOND SYSTEM
UP TO 16 DUPLEX 60-WPM TELEGRAPH CHANNELS CAN BE OPERATED ON ANY FULL CHANNEL. UP TO 9 CAN BE OPERATED ON THE ADDITIONAL HALF CHANNEL OF A TYPE 32 LENKURT SYSTEM.
WEST TO EAST OR NORTH TO SOUTH TRANSMISSION
EAST TO WEST OR SOUTH TO NORTH TRANSMISSION
PILOT FREQUENCY
CARRIER OSCILLATOR FREQUENCY

LENKURT ELECTRIC CO.
SAN CARLOS • CALIFORNIA



Easy to use—Low in cost!

NEW—yet field reports already indicate that TANNATHIN represents a vast stride forward in the industry's search for an all purpose mud-treating chemical.

A *MULTI-PURPOSE CONDITIONER*—TANNATHIN is a powerful dispersing agent for:

1. Lowering viscosity and Gel strength.
2. Improving wall building properties
3. Acting as a protective colloid which protects mud against contamination encountered during drilling.

EASY TO USE—Simply mix TANNATHIN with water and add to the mud.

LOW IN COST—TANNATHIN is consistent with Magcobar's successful effort to provide the industry with the best drilling mud at LOW COST. TANNATHIN currently sells for approximately one-half that of other complex organic compounds that are used in treating mud.

Your Magcobar engineer will gladly explain how TANNATHIN may be used in both normal muds and high pH lime muds as a means of simplifying your treating problem and lowering your mud costs.

Magcobar
Complete
DRILLING MUD SERVICE
DEALER

Look for this sign **WHEN YOU NEED MUD**

MAGCOBAR • MAGCOGEL • HIGH YIELD DRILLING MUD • XACT CLAY • MAGCO-FIBER • MAGCO-MICA • TANNATHIN • JEL-OIL MUD • JEL-OIL "E" • SALT GEL • NOHEEV SEAL FLAKES • MY-LO-JEL • CHEMICALS

MAGNET COVE BARIUM CORPORATION

Malvern, Arkansas - Houston, Texas

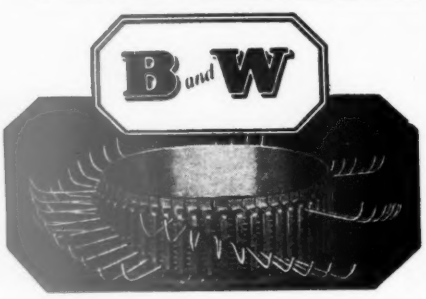
Export Representative: Guy E. Daniels, 30 Rockefeller Plaza
New York, N. Y.

BETTER PIPE TOOLS

"ARMSTRONG BROS." Pipe Dies and Chasers are machined from special alloy steel, are heat treated and oil tempered. Cutting teeth are "backed-off" with ground points—cut faster, cut easier, cut smooth, tight-fitting threads. They come in "Solid," "Adjustable" and "Receding" types to fit all standard make stocks and threaders. Standardize on "ARMSTRONG BROS." Dies and Chasers for better thread cutting.

Stocked by Leading Tool Departments

ARMSTRONG BROS. TOOL CO,
5231 West Armstrong Avenue
Chicago 30, U.S.A.
New York
San Francisco



PATENTED AND PATENTS PENDING

B & W Wall Cleaning Guides are effective—and safe—in cementing even the deepest wells.

.DON'T SQUEEZE!

It Ties Up Your Rig.

BRUCE BARKIS — B and W INCORPORATED — KENNETH WRIGHT

Well Completion Specialists

HOUSTON, TEXAS • LONG BEACH, CALIF.

Rockwell chief engineer

Rockwell Manufacturing Company announces the appointment of E. E. Hedene to chief engineer of all operations of the Nordstrom Valve Division. He was formerly the chief engineer of the Nordstrom Valve plant at Oakland, California, where for the major part of his 22 years' service he worked directly with Sven Nordstrom, the inventor and developer of the Nordstrom lubricated plug valve.

E. E. Hedene

Hedene will have his headquarters at the company's general office at Pittsburgh. His duties will include considerable field work in addition to coordinating the Nordstrom engineering activities at the Pittsburgh, Hopewell, Oakland, and East Chicago plants.

Hedene studied mechanical engineering at the University of California, and was affiliated with several West Coast engineering firms before coming to Nordstrom.

Thomas promoted

Sheldon Thomas, former assistant to Robert W. Ward, vice president in charge of production of American Car and Foundry Company, has been appointed assistant district manager of the company's Chicago, Illinois, plant.

Sheldon Thomas

Prior to coming to ACF Thomas served in various capacities as construction superintendent for an electrical contracting firm, as machine and pattern shop superintendent, and subsequently as draftsman in the engineering department of the Burndy Engineering Company.

He began work with ACF in 1940 as electrical draftsman and later was assigned field engineer for the improvement department. In 1944 he was transferred to the office of vice president where he has since been engaged with matters pertaining to manufacturing and production.

Opens new store

The Wilson Supply Company, Houston, Texas, announces the opening of its new store at Houma, Louisiana on September 1. W. C. (Bill) Johnson, manager of the new store, is widely known in oil field and supply circles in Southern Louisiana and Mississippi. H. E. Jordan is assistant store manager, with Charles Tuminello, field salesman, and Frank Anders, warehouseman.

The new store at Houma gives the Wilson Supply five stores in Louisiana: Houma, Lake Charles, New Iberia, Shreveport, and Harvey.

W. G. (Doc) Akins is district manager for Southern Louisiana.

Assistant vice president

Henry V. Bootes, formerly district sales manager, New York sales district, has been appointed assistant vice president of American Car and Foundry Company, it is announced by Frederick H. Norton, vice president in charge of sales for ACF. Bootes will continue to make his headquarters in New York.

Henry V. Bootes

Prior to coming to ACF in 1947 he was district manager of The Ohio Injector Company. During World War II he saw combat duty in the South Pacific area where he served as a major in the Marine Corps.

TREAT the WATER

AND YOU HELP THE MUD!

•

A new approach to help solve mud problems.

• SOLITE is a product specifically formulated to condition water for use in drilling mud.

A laboratory with trained personnel is available to users of SOLITE to assure efficient use of the product.

PAGE TESTING LABORATORY
NORTH VENTURA AVENUE • P. O. BOX 461
VENTURA, CALIFORNIA

21 YEARS "PUTTING PERMANENCE IN PIPE"

You can't laugh off 21 years experience in doing one job well . . . PUTTING PERMANENCE IN PIPE. We've coated and wrapped more than 150 million feet.

PIPE CLEANING, COATING AND WRAPPING TO ANY SPECIFICATION

MAYES BROS.

INCORPORATED

HOUSTON, TEXAS

CRUDE, CRACKED AND VOLATILE

The young man wrapped his arms around the pretty girl.

"My darling," he breathed, "you're all the world to me. I don't know what I'd do without you. I love——"

At that moment the door-bell rang. The girl jumped up. "It's my fiancé," she gasped. "You must leave at once. Oh, hurry!"

The young man looked around nervously.

"But how am I going to leave?" he asked anxiously. "I can't go out by the door. Your fiancé would see me."

The girl thought quickly.

"Jump out the window," she advised.

"But we're on the thirteenth floor."

The girl stamped her foot. "So what?" she rasped. "At this stage are you going to tell me you're superstitious?"

* * *

A conductor was driven crazy at rehearsals because at least one member of the orchestra was always missing. After the last rehearsal he tapped his baton for attention and said, bitingly: "I want to thank the first violin publicly for being the only man in the orchestra who had the decency to attend every rehearsal."

The first violin hung his head and looked sheepish. "It seemed the least I could do," he said in a deprecating tone. "You see, I don't expect to show up for the concert tonight."

* * *

A colonel and a major were sitting in a Washington cafe. Across the way sat a PFC and a lovely lass. The colonel's interest prompted him to send this note to the private:

"I believe I studied with you at Yale, and the major thinks he studied with you at Princeton. Please come across and straighten us out."

The private replied, by note: "I didn't study at Yale or Princeton, but I did study at the National School of Taxidermy and I'm taking care of this pigeon myself."

* * *

A young medical lieutenant who walked past the psychiatric ward each morning and watched one of the inmates go through the motions of winding up and pitching an imaginary ball. was finally asked by one of his friends why he stopped daily and watched the screwball go through his act.

"Well," he answered, "if things keep going the way they are, I'll be in there some day catching for that guy, and I want to get on to his curves."

* * *

There was a heated argument going on in the courtroom one day. The case involved a woman who was hit by a car. The defending lawyer, eager to get his client's innocence across to the jury, said, "Mr. Smith couldn't be wrong; he's been driving cars for 15 years."

The prosecuting attorney, always a shrewd talker, countered quickly with: "In that case my client is certainly right. You see, she's been walking for 40 years."

* * *

Walking down the street with a friend one day, a professor passed a large fish store where a fine catch of codfish, with mouths wide open and eyes staring, were arranged in a row. The professor stopped, looked at them, and clutching his friend by the arm, exclaimed: "Heavens, that reminds me—I should be teaching a class."

* * *

A good leader hammers home his message constantly—like the preacher who thus described his sermon: "I get up and tells 'em what I'm goin' to tell 'em, and then I tell 'em, and then I tell 'em what I've told 'em.'

* * *

Motorist (barely avoiding a broadside crash): Why on earth didn't you signal that you were turning in?

Girl (who has just crossed into her home driveway): I always turn in here, stupid.

* * *

"Well, what excuse have you got for coming home at this hour of the night?"

"Well, my dear, I was playing golf with some friends and . . ."

"What? At 2 a.m.?"

"Sure. We were using the night clubs."

* * *

Student: I hear the Board of Trustees is trying to stop necking.

Co-ed: That so? First thing you know they'll be trying to make the students stop, too.

* * *

"Is Jim a confirmed bachelor?"

"He is now. He sent his picture to a Lonely Hearts Club and they sent it back with a note saying: 'We're not that lonely'."

* * *

Boss (to stenographer): Are you doing anything Sunday evening, Miss Hanson?

Stenographer (hopefully): Why, no.

The Big Brute: Then try to get down earlier Monday morning, will you?

* * *

Frank: I understand your girl friend is a typist. Does she use the touch system?

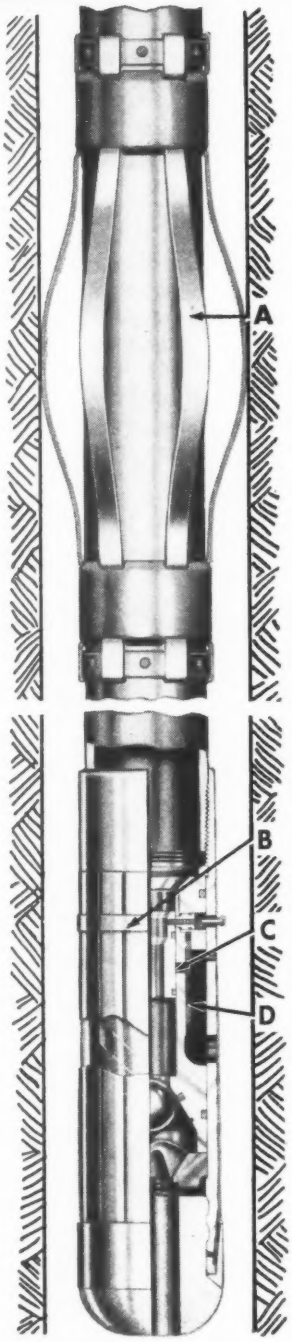
Bill: You don't think she bought all those swell duds out of her salary, do you?

WITH A

BAKER *Triplex* CEMENTING SHOE...

You secure a good "first-time" cement job while protecting permeable low-pressure zones below the shoe from contamination.

Here's how it is done . . .



A Baker Casing Centralizers (Product No. 910) are installed on, and above, the shoe joint to center the casing and provide a uniform annulus to receive the cement slurry.

B A hold-down strap (secured by shear screws) retains the Baker Metal Petal Basket close against the shoe or collar while running-in the casing and conditioning the hole.

C Cementing ports are covered by the Tripping Valve until cementing is commenced.

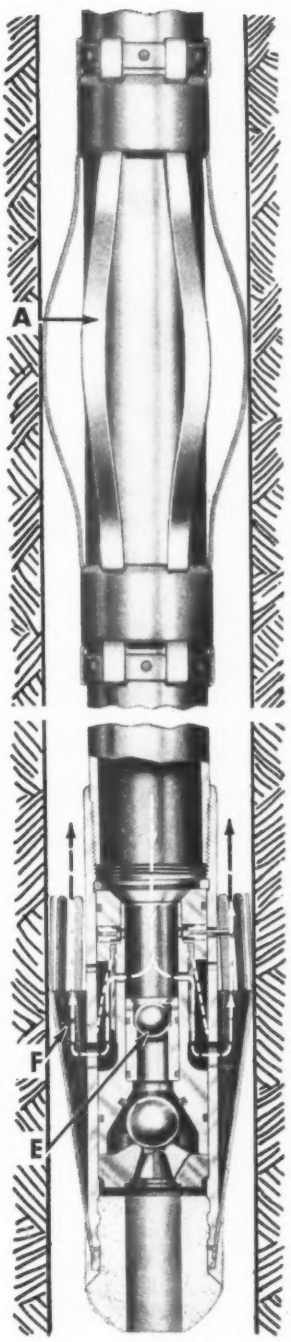
D A fabric-reinforced, resilient rubber, sleeve-type, back-pressure valve opens readily (see dotted white line) to permit passage of the cement slurry into the annulus above, but closes instantly to prevent any return flow of the slurry.

E After reaching the desired point in the hole, circulation is established through the ample central passageway. A Tripping Ball now is pumped (or allowed to gravitate) down the hole to seat upon the Tripping Valve. Pressure of 400 to 500 psi is applied to the casing, which shears the Tripping Valve shear screws and forces the Tripping Valve downward to expose the cementing ports.

F Shearing the screws also releases the Basket hold-down strap and allows the Metal Petal Basket to expand outwardly against the wall of the hole. The Basket with which each Triplex Shoe is equipped has a wide range of expansion and forms a bridge in large-diameter, or irregular-shaped holes far beyond the range of a rubber packing element.

The cementing operation now is carried out in the conventional manner with the cement slurry directed upward with the exclusive Baker "Whirler" action. This "Whirler" principle has proved to be far superior to an undirected jetting action which does not minimize the hazard of channeling, and may wash out cavities and cause cement contamination.

Only readily drillable materials are used for all internal parts; and two one-half inch set screws hold the inner assembly stationary to facilitate drilling out.



BAKER OIL TOOLS, INC.

HOUSTON • LOS ANGELES • NEW YORK

FOR A COMPLETE DESCRIPTION AND ILLUSTRATION REFER TO PAGE 423 OF THE 1948 COMPOSITE CATALOG OR THE 1948 BAKER CATALOG

BAKER *Triplex* **CEMENTING SHOE**

running tour with men in the industry

▸ **Robert M. (Bob) Vilsack** has joined the sales department of Taylor Forge and Pipe Works, reporting to the main plant at Chicago, Illinois. The company also operates extensive properties at Carnegie, Pennsylvania, and Fontana, California. Vilsack was recently associated with the M. W. Kellogg Company of New York in engineering and sales work.

R. M. Vilsack

▸ **W. E. "Ed" Larson** and **Lloyd Calhoun,** engineers of the McCullough Tool Company, Los Angeles, attended the second dinner meeting of the Coast Geological Society at Eaton's restaurant, Santa Barbara, August 9. Calhoun presented a timely talk and slide films on the "Application of Electronics in Oil Wells." Certain McCullough electronic tools were discussed in detail, including the Magna-Tector, Surface Recording Pressure Bomb Equipment, and the Sonic Device.

About 60 geologists and engineers from all parts of the state were present.

▸ **J. Dock Mumford** of Orbit Valve Company, Tulsa, Oklahoma, spent the last two weeks of August in Rocky Mountain area, making his headquarters in Casper, Wyoming.

▸ **Stephen G. Paddock,** assistant sales manager, Burgess-Manning Company, Libertyville, Illinois, visited the trade in Houston, Texas, and Tulsa, Oklahoma, during August.

▸ **John M. B. Howard** has been appointed assistant manager of Standard-Vacuum Oil Company's marine department. Howard, a graduate of the United States Naval Academy, had extensive experience with Jersey Standard's world-wide marine operations prior to joining Standard-Vacuum. Beginning as a deck officer on tankers in 1933, he later received his master's papers and went on to occupy important shore posts at New York, Baltimore, Baton Rouge, Houston, Caripito, Aruba, and other well-known oil ports.

His most recent assignment was in London, as assistant general manager of Esso Transportation Company, a Jersey Standard affiliate. In his new connection he will assist **W. F. Dunning** in handling the owned and chartered tankers that fly the "Stanvac" flag throughout the Far East.

▸ **C. D. Miller,** executive vice president, The British-American Oil Producing Company, announces the following changes in personnel in the western division:

O. I. Torkelsen, at present Manager of exploitation of the western division, appointed vice president in charge of western division.

J. E. Matter, at present chief geologist, western division, appointed vice president in charge of exploration of western division.

J. E. Matter

O. I. Torkelsen

O. W. Ward, at present production superintendent for the San Joaquin Valley, appointed production superintendent for the western division, with headquarters in Los Angeles.

M. V. Adams, at present petroleum engineer for the San Joaquin Valley, appointed production superintendent for the San Joaquin Valley, with headquarters in Bakersfield.

▸ **A. H. Hayes** has been promoted to assistant general superintendent of the Whiting, Indiana, refinery of Standard Oil Company (Indiana) to succeed **J. C. Ducommun,** who, as previously announced, became refinery manager July 12. Hayes joined the company in 1930 as a chemist in the Whiting research laboratory. After serving also in the pressure-still and crude-still departments at the Whiting refinery, he became superintendent of the light oils division at the refinery in 1946.

▸ **D. T. O'Connor,** export sales representative of Shaffer Tool Works and Telematic Corporation, left on September 2 for Venezuela, Colombia, Ecuador, Peru and Trinidad, where he will visit all of the principal oil field operations.

▸ **George S. Ames** has been appointed special representative of the service department of Findlay Division of Gar Wood Industries, Inc. Ames will be on call to assist pipe line contractors on service and parts problems. Ames formerly was associated with various oil field contractors. His vast experience should be an asset to the pipeliners and dealers he will service.

George S. Ames

▸ **Ray Althouse** of Bartlesville, Oklahoma, has been elevated to the position of executive assistant in the Cities Service Oil Company's executive department. Althouse formerly was office manager for the oil production division at Bartlesville. He entered service of the company on February 1, 1927. **M. R. Shaffer, Jr.,** has assumed the duties of office manager in the oil production division. He was first employed by Cities Service in 1939.

Gerald R. Preston of Bartlesville, assistant treasurer of the company and in charge of the acquisition of producing property, has named **A. W. Page, Jr.,** his assistant.

Increased operations, according to **M. J. Kirwan,** manager oil production division, have made necessary the appointment of an assistant for **C. E. Beecher** of Bartlesville, general superintendent. This new position will be filled by **Jack A. Cleverley** of Oklahoma City, assistant division superintendent of the oil production division at Oklahoma City.

E. E. Ives of Oklahoma City, formerly assistant division superintendent for southern Oklahoma, Seminole, and northern Texas, will be assistant division superintendent for the Oklahoma City and Seminole districts.

Glenn Harsh of Oklahoma City assumes the duties of assistant division superintendent for the southern Oklahoma and northern Texas districts.

Robert C. Cooper, formerly acting superintendent for western Kansas, has been named assistant division superintendent in charge of that area.

Jack G. Coates of Bartlesville has been transferred from the ad valorem tax department to the crude oil purchasing and sales department as crude

oil representative in the West Texas and New Mexico area. He will be stationed at Midland, Texas.

New buyer for the purchasing and stores department is **Gerald McGrew,** who has been transferred from the engineering department. **John D. Forsyth** has been named to take over McGrew's duties in the engineering department.

▸ **Jack Clemens,** Martin-Decker Gulf Coast sales and service representative, who recently became a member of the Houston chapter of Nomads, has completed a combined business and pleasure trip to the West Coast. Besides spending his vacation in California, Jack devoted considerable time and study to Martin-Decker's latest product developments at the company's Long Beach plant. **"Mutt" Donovan,** Martin-Decker Mid-Continent sales and service representative, with headquarters at Oklahoma City, is on a business trip to the Rocky Mountains and Canada. **Ben Hanly,** Reed Roller Bit Company representative, Casper, Wyoming, is accompanying him to Calgary fields.

▸ **E. R. Baker,** widely experienced industrial chemist and wartime assistant research chief in chemical warfare, has been appointed manager of Continental Oil Company's newly created Central Research Laboratories, it is announced by **L. L. Davis,** manager of the company's Development and Research Department. Baker comes to Continental from Emery Industries, Inc., of Cincinnati, Ohio, where he was director of development.

E. R. Baker

▸ **Dr. Harold A. Beatty** has been appointed to the newly-created position of assistant director of research at the Ethyl Corporation Research Laboratories in Detroit. Dr. Beatty, who has been associated with Ethyl Corporation for the last 17 years, will assist the director of research, **John B. Macauley,** in the overall guidance of research and technical service activities.

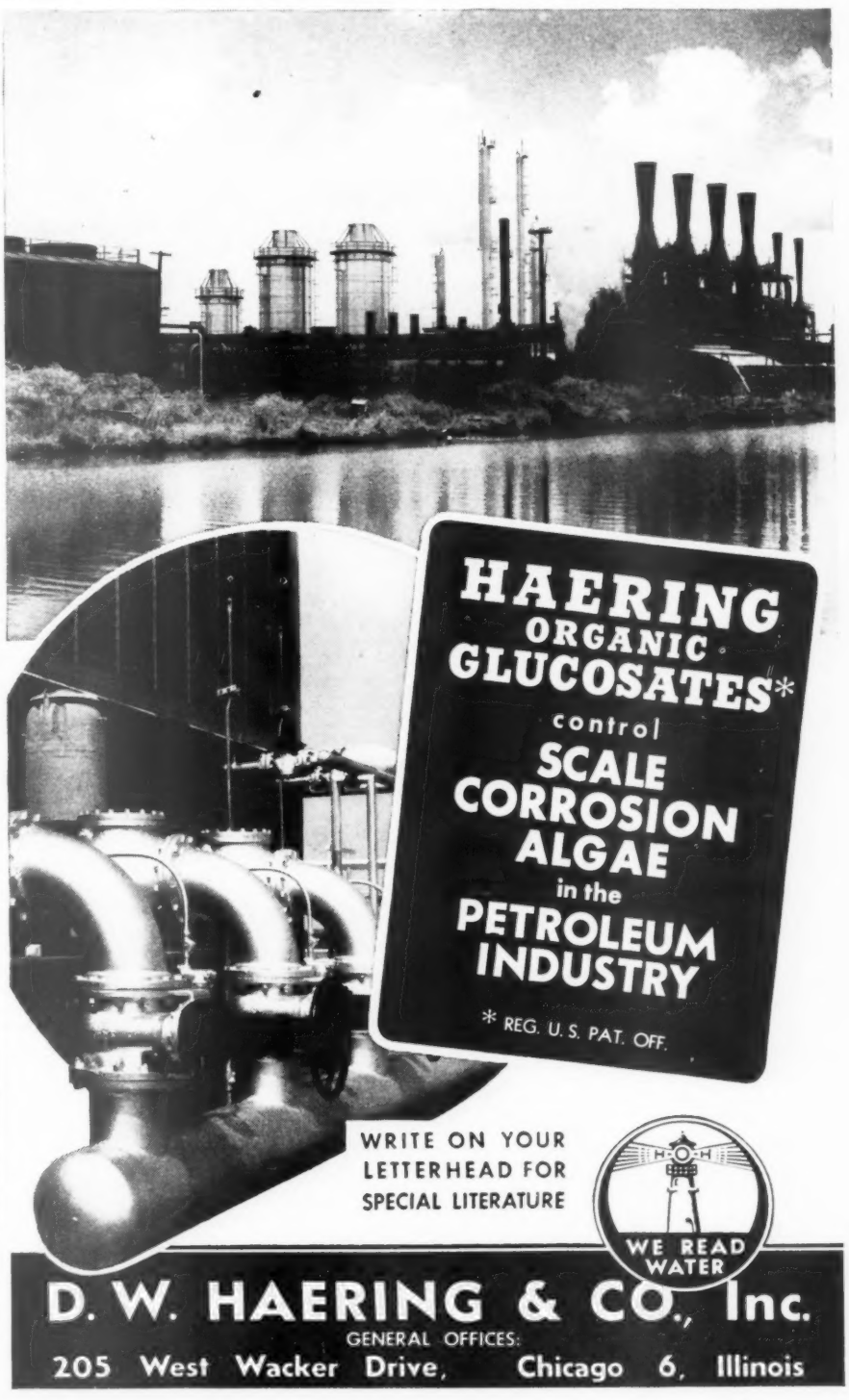
Previous to his new assignment, Dr. Beatty was technical assistant to the general manager at the Ethyl Laboratories. He has been succeeded in that position by **Dr. O. Edward Kurt,** who has transferred to Detroit from Baton Rouge, Louisiana. Dr. Kurt has been associated with Ethyl Corporation for 12 years, the last seven as manager of the development section at the "Ethyl" antiknock compound manufacturing plant in Baton Rouge.

▸ **Charles R. Brown** has been appointed a vice president of Tide Water Associated Oil Company, according to announcement by **President William F. Humphrey.** Brown has served as assistant to the president for many years and is a member of the company's western division operating committee. He shall continue his general administrative duties with direct responsibility for many of Tide Water Associated's administrative departments in the Western Division.

▸ **K. F. Krammes** has been promoted to district geologist in the Bakersfield area of The Texas Company. Krammes succeeds **L. B. Snedden** who has been transferred to Houston, Texas, as assistant manager of the geophysical division, producing department.

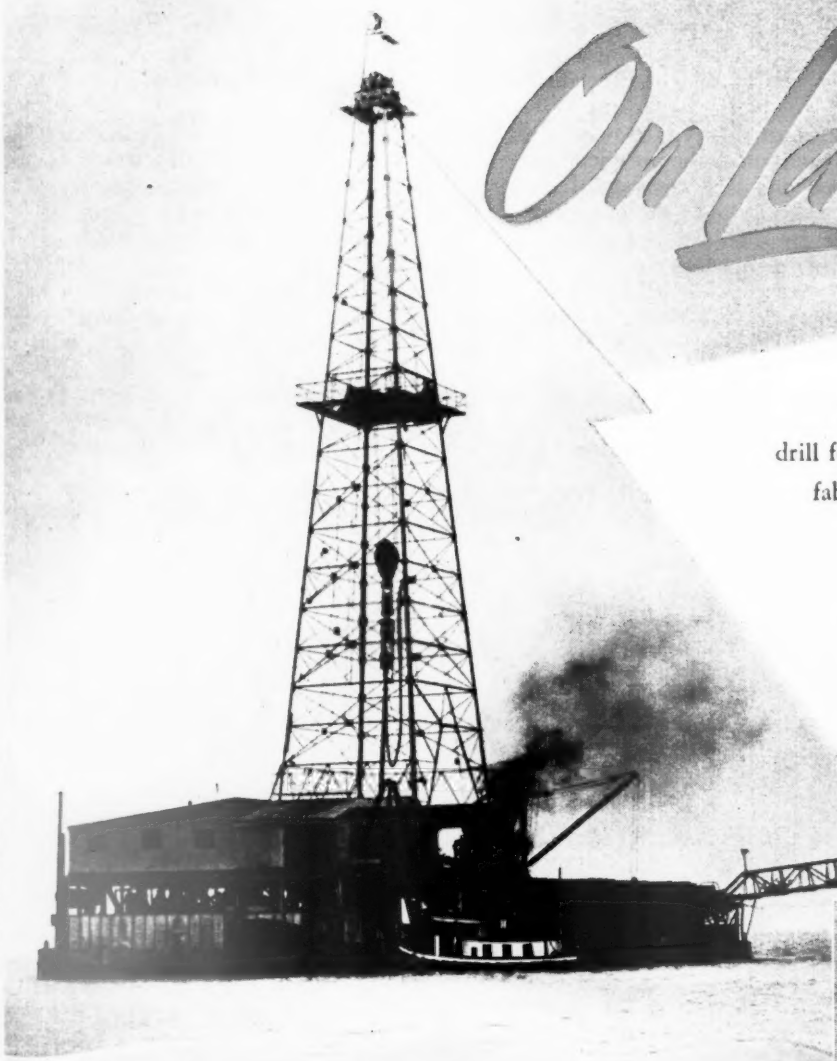
▸ **A. Kolstad,** of Kolstad Engineering and Sales Company, Long Beach, California, has been appointed sales representative for Thomas C. Wilson, Inc., manufacturers of tube cleaning equipment.

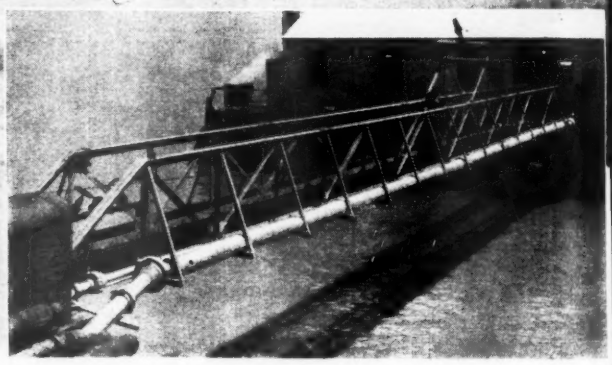
▸ **N. N. Jones,** district superintendent for Humble Oil and Refining Company at Gladewater, Texas, has been transferred to the same position in the Andrews district, West Texas division. The new Gladewater superintendent is **W. W. Phillips,** former



On Land or Sea

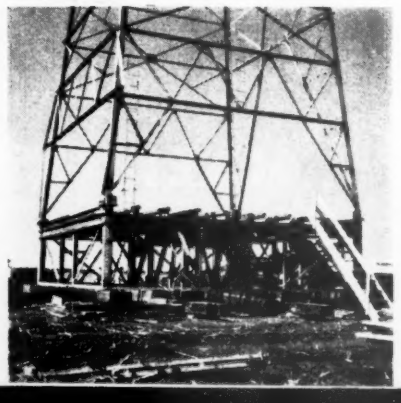
Deep or shallow... on land or sea... Emsco structural products are being used wherever men drill for, and produce oil. Emsco has designed, engineered and fabricated a wide range of structural steel products to aid all drilling and producing operations. Emsco has unsurpassed facilities for the fabrication of structural products to your specifications. Ask your nearest Emsco representative for complete information today!





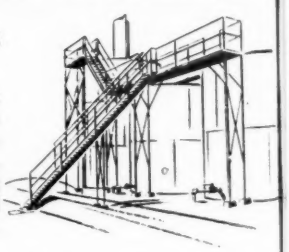
Drilling barge equipped with 136' high, 30' base, Emsco Type 18AR derrick. Note Emsco gin pole assembly, quadruple safety platform and 1st girt landing platform. Inset at right shows Emsco walkway used to connect drilling barge with boiler barge. Walkway is hinged permitting it to be raised during moving or when rough weather is encountered. Walkway supports pipe lines connecting barges.

Looking up 136', Emsco 18AR derrick equipped with Emsco 14GP, 16,600 lb. capacity gin pole assembly. Also note Emsco tong hangers and quadruple safety platform.

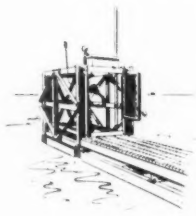


Rigging up an Emsco derrick on a 10' high, Emsco 60HX substructure. This substructure is designed for deep drilling operations requiring heavy, bulky blowout equipment and racking of large amounts of pipe on derrick floor. It is well suited for skidding operations.

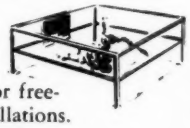
MISCELLANEOUS STRUCTURAL PRODUCTS



TANK WALKWAYS—tank and gun barrel walkways and stairs are fabricated to meet specific requirements. Hot dip galvanizing insures long life and low maintenance.



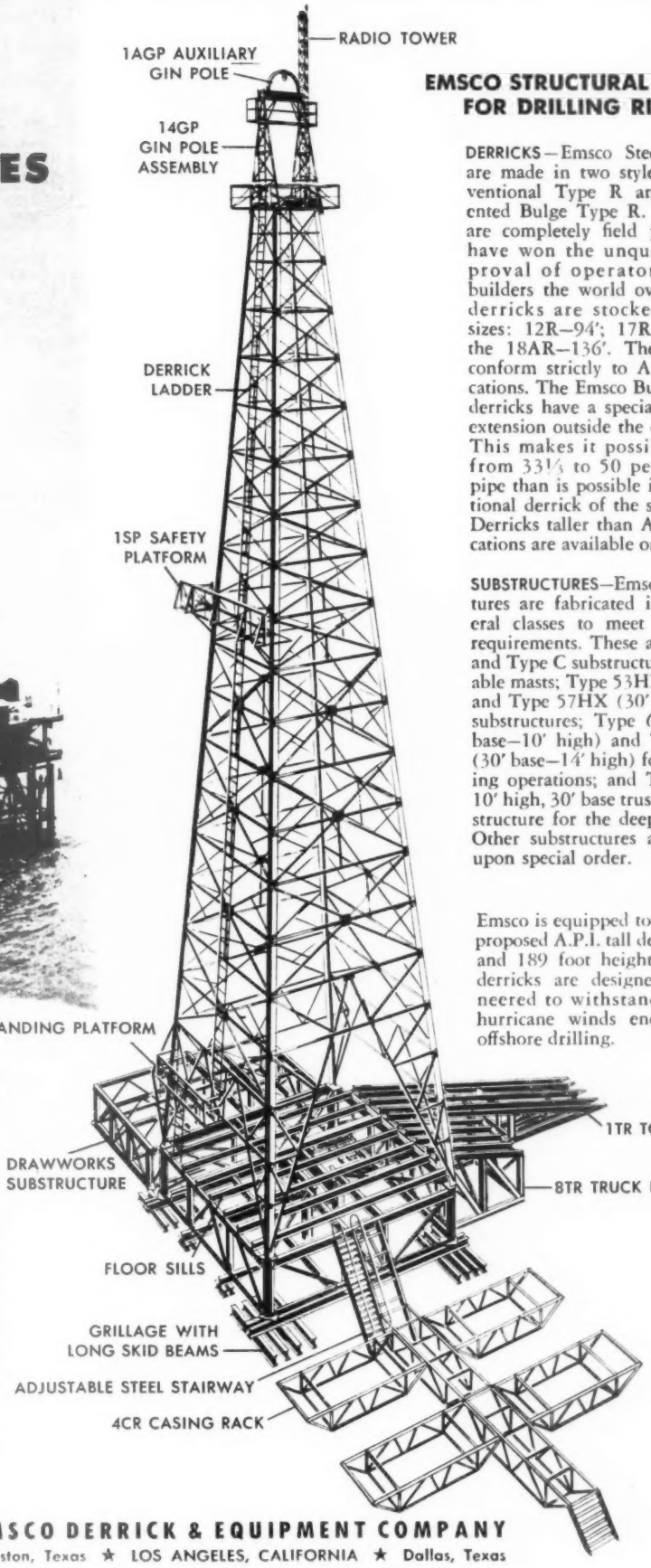
COMBINATION GUIDE CHUTE, WELL GUARD AND BOAT LANDING—protects offshore wells against damage from boats or heavy floating drift. Boat landing facilitates servicing of well.



WELL FENCES—available for free-flowing or pumping installations. Fences for free-flowing wells are of two types: a light unit for use as a cattle guard; and a heavier type for locations subject to flooding to protect well head from floating drift.

EMSCO DERRICKS AND SUBSTRUCTURES MEET ALL DRILLING REQUIREMENTS

erial view of offshore
rilling location using
msco 18AR, 136'
errick and other
tructural accessories.



EMSCO STRUCTURAL ITEMS FOR DRILLING RIGS

DERRICKS—Emsco Steel Derricks are made in two styles—the conventional Type R and the patented Bulge Type R. Both styles are completely field proven and have won the unqualified approval of operators and rig builders the world over. Type R derricks are stocked in three sizes: 12R—94'; 17R—129'; and the 18AR—136'. These derricks conform strictly to A.P.I. specifications. The Emsco Bulge Type R derricks have a special "set-back" extension outside the derrick legs. This makes it possible to rack from 33⅓ to 50 percent more pipe than is possible in a conventional derrick of the same height. Derricks taller than A.P.I. specifications are available on order.

SUBSTRUCTURES—Emsco substructures are fabricated in four general classes to meet all drilling requirements. These are: Type M and Type C substructures for portable masts; Type 53HX (24' base) and Type 57HX (30' base) A.P.I. substructures; Type 60 HX (30' base—10' high) and Type 75HX (30' base—14' high) for deep drilling operations; and Type 80HX, 10' high, 30' base trussed type substructure for the deepest drilling. Other substructures are available upon special order.

Emsco is equipped to fabricate the proposed A.P.I. tall derricks in 140 and 189 foot heights. These tall derricks are designed and engineered to withstand the severe hurricane winds encountered in offshore drilling.

PARTIAL LIST OF EMSCO STRUCTURAL PRODUCTS • A.P.I. DERRICKS • SPECIAL DERRICKS A.P.I. SUBSTRUCTURES • PORTABLE MASTS AND SUBSTRUCTURES • CUSTOM BUILT SUBSTRUCTURES • ENGINE SUBSTRUCTURES • GIN POLES • AUXILIARY GIN POLES • SAFETY PLATFORMS • TUBING BOARDS • TONG HANGERS • DERRICK LADDERS • DERRICK LANDING PLATFORMS • DEADLINE ANCHORS • STEEL STAIRWAYS • TRUCK RAMPS • TOOL RAMPS CASING RACKS • KELLY SLIDES • BARGE WALKWAYS • BOAT LANDINGS • SAFETY GUARDS • SLUSH PIT SUCTION SCREENS SWAMP WALKWAYS • COMBINATION WELL GUARD, BOAT LANDING AND GUIDE CHUTE • WELL FENCES • PUMPING UNIT FENCES • TANK WALKWAYS • SEPARATOR TOWERS RADIO TOWERS • TRANSMISSION TOWERS • FLOODLIGHT AND LOOKOUT TOWERS • FLARE TOWERS • WATER TANK TOWERS • SUBSTATION STRUCTURES.

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assistant district superintendent at London. **P. L. McGee,** assistant district superintendent at Pickton, was transferred to the London district to replace Phillips.

A. J. Bedford, assistant division chief clerk of the Southwest Texas division, has been promoted to division chief clerk of the West Texas division, and **H. J. McDonald,** district chief clerk at Government Wells, was promoted to Bedford's former position.

B. A. True, assistant district chief clerk at Kelsey, has been promoted to district chief clerk at the Kelsey gas plant construction district. New district chief clerk for the Seeligson gas plant construction district is **M. A. Banner,** former district clerk at Stratton.

E. J. Stanley, roustabout, London district, has been promoted to the Gulf Coast division office in Houston as junior civil engineer.

Norman Newsome, associate petroleum engineer, petroleum engineering division, Houston office, has been promoted to petroleum engineer in the Friendswood district.

J. O. Coburn, tool pusher, of the Galveston Bay district has been transferred to the Lovell Lake district.

T. O. Allen is now a senior petroleum engineer in the petroleum engineering division, Houston office. He formerly held the same position in the Gulf Coast division office.

J. E. Bray, junior civil engineer in the East Texas division office at Tyler, has been transferred to the Gulf Coast division office in Houston.

In the Louisiana division, **G. K. Myrhaugen,** district civil engineer, has been transferred from Avery Island to Bayou Sale. **W. M. Satterwhite,** tool pusher, has been transferred from Avery Island to Eucutta; **E. A. Bullington,** district civil engineer, has been transferred from Bayou Sale to the Louisiana davision office in New Orleans; **C. C. Pyle,** assistant chief clerk, from Bayou Sale to Grand Isle, and **W. H. Arnold,** tool pusher, from Hub, Mississippi, to Grand Isle, Louisiana.

James P. Malott has been promoted from region petroleum engineer to assistant region manager of the Houston region of Continental Oil Company's production and drilling department. **Edwin A. Austin,** formerly district petroleum engineer at Basile, Louisiana, has been named to succeed Malott.

J. P. Malott

Malott, who went to Houston in 1939 as petroleum engineer, has been with Continental since 1935. He joined Continetal as a roustabout at Jal, New Mexico, and served in that state as utility man, head roustabout, junior petroleum engineer, and then petroleum engineer.

Since joining Continental as a roustabout in Tepetate, Louisiana, in 1939, Austin has risen through various field assignments in the same state. He served five years in the Army.

V. W. Fletcher, who has been manager of the material department of the Shell Company of Ecuador, Ltd., for the last 2½ years, has been transferred to the Shell Company of Colombia, where he will also be in charge of materials. Accompanied by Mrs. Fletcher, he left for Bogota on August 15. Although Fletcher will be permanently stationed in Bogota, he is only staying there for a few weeks to begin with, as toward the end of September he and Mrs. Fletcher will leave for the United States en route to British Borneo. They will stay in Borneo for three or four months, during which time Fletcher will supervise the materials organization of Shell's subsidiary in Brunei. Upon completion

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of this assignment, the Fletchers will return to their post in Bogota, Colombia.

▸ **Derek Allan Hough** has been appointed general secretary of the Institute of Petroleum, London, England.

George Sell has been appointed editor of the Institute's publications. Sell has been publications secretary since March, 1946.

▸ **John J. (Jerry) Willenburg** has been promoted from assistant area superintendent to superintendent in charge of all operations in Illinois and Indiana by the Stanolind Pipe Line Company. The Illinois-Indiana portion of Stanolind's line transports crude oil from New Mexico, Texas, Oklahoma, Kansas, and Wyoming to refineries in the Chicago area including the Standard Oil Company (Ind.) refinery at Whiting, Indiana.

J. J. Willenburg

Willenburg, among the youngest of the top executives in Stanolind Pipe Line Company's field administrative organization, succeeds **C. E. Sender,** who retired August 14 after 31 years' active service. Illinois-Indiana headquarters will continue to be Galesburg, Illinois.

▸ **T. L. Tiernan** has been named manager of Sunray Oil Corporation's refinery at Allen, Oklahoma. Tiernan formerly was assistant superintendent of the plant and started with Sunray in 1933 as an electrician. He succeeds **Dewey Vinson,** who has been transferred to the company's Duncan refinery.

F. L. Martin, executive vice president in charge of the refinery division, has announced a complete new alignment of management supervision at the Allen plant with the following appointments: **Ault Milne,** former stillman, will be plant superintendent; **Luther Jones** and **Edgar Dean,** both former stillmen, will be assistant superintendents; **Carl F. Kile,** formerly a treater, has been named foreman of treating, blending, and loading racks; **Herman C. Kraettli,** formerly engine mechanic, has been named mechanical foreman.

▸ **Rober Henquet** and **Bob Ford** of Schlumberger Well Surveying Corporation, Houston, Texas, flew to London on August 23 as Schlumberger delegates to the International Geological Conference. They were to be back in the U. S. about the first of September.

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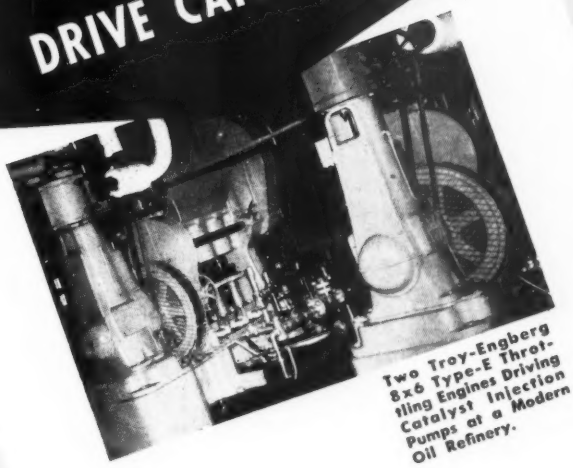

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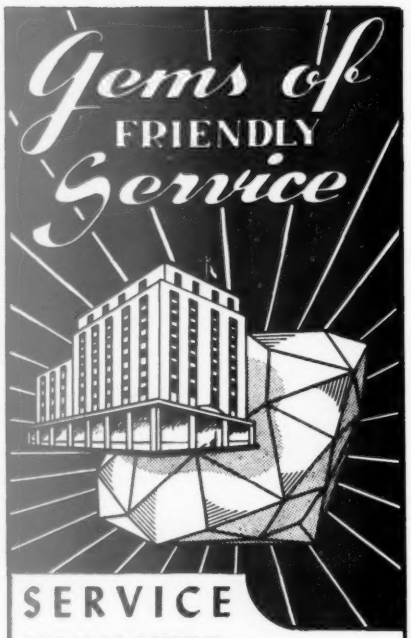

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Casper office

To facilitate servicing the Rocky Mountain district for Black Magic oil base drilling fluid, and for Koebelite diamond core bits and barrels, Oil Base, Inc., Compton, California, moved its offices from Vernal, Utah, to Casper, Wyoming, on September 1. A. K. "Deacon" Brown is in charge of the Casper office, supervising mud and diamond coring programs in Wyoming, Colorado, Utah, Montana, and wherever developments require personal attention.

Vennema transferred

Schlumberger Well Surveying Corporation, Houston, Texas, has announced the transfer of Ame Vennema to the Houston headquarters to take charge of the company's personnel department. Vennema was formerly assistant division manager of the Louisiana division for Schlumberger with offices in New Orleans.

Firm reorganized

The formation of Consolidated Western Constructors, Inc., with offices in the M & M building, Houston, Texas, is announced by Harvey C. Cranfill, vice president of Consolidated Western Steel Corporation, which was purchased by United States Steel Corporation, according to an announcement made by Benjamin F. Fairless, president of U. S. Steel.

Consolidated Western Constructors, Inc., was formerly the construction division of the Consolidated Steel Company of Texas, at Orange, which firm was included in the purchase by U. S. Steel. The new company has been reorganized to specialize in the complete design, engineering, and construction of natural gas and petroleum processing plants.

The officers of Consolidated Western Constructors, Inc., are almost identical with their parent company, the exception being William E. Goodere who has been transferred from the Los Angeles office and named vice president in charge of operations at Houston.

George F. Russell, Jr., consulting chemical engineer, has been appointed manager of the natural gas and gasoline division. He brings into the organization more than 15 years of varied experience in the field of natural gas processing and production. He was formerly associated with the Hudson Engineering Corporation, Standard Oil of New Jersey's Louisiana division, and Phillips Petroleum Company; and was assistant professor of chemical engineering at the University of Oklahoma and associate professor of natural gas and petroleum engineer at Louisiana State.

T. C. Main is a new member of the design staff of Consolidated Western, being chief chemical and process design engineer. He was formerly chemical engineer in charge of research and development for Fomac Engineers in McCarthy chemical and absorption plants at Winnie, Texas. Prior experience included five years as chemical engineer with the Esso laboratories of the Standard Oil Company of New Jersey's Louisiana division.

George E. Little, formerly with Brown and Root Construction Company, has been placed in charge of the estimating group. He is a graduate mechanical engineer from the University of Akron.

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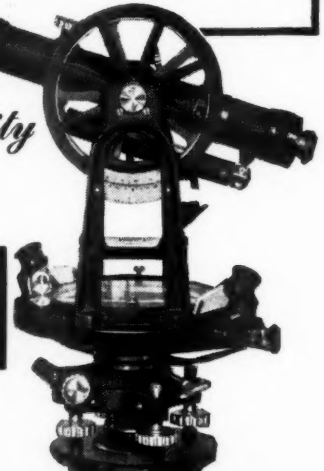

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The Continuous Tables have been developed as a result of suggestions for new tables, direct contributions and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue; 73-79, inclusive, in the January, 1944, issue; 80-82, inclusive, in the April, 1944 issue; 83-85, inclusive, in the July, 1944, issue; 86-88, inclusive, in the October, 1944, issue; 89-91, inclusive, in the January, 1945, issue; 92-94, inclusive, in the April, 1945, issue; 95-97, inclusive, in the July, 1945, issue; 98-100, inclusive, in the October, 1945, issue; 101-103, inclusive, in the January, 1946, issue; 104-106, inclusive, in the April, 1946, issue; 107-109, inclusive, in the July, 1946, issue; 110-112, inclusive, in the October, 1946, issue; 113-115, inclusive, in the January, 1947, issue; 116-118, inclusive, in the April, 1947, issue; 119-121, inclusive, in the July, 1947, issue; 122-124, inclusive, in the October, 1947, issue; 125-127, inclusive, in the January, 1948, issue; 128-130, inclusive, in the April, 1948, issue; 131-133, inclusive, in the July, 1948, issue.

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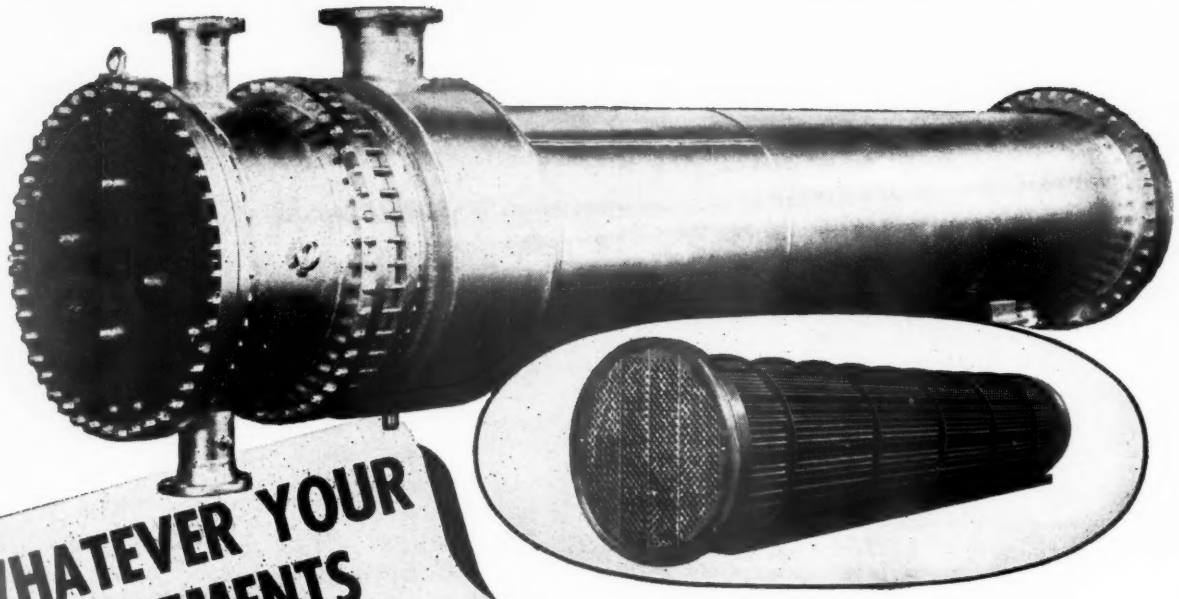

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FACTORS IN THE SELECTION AND USE OF SUCKER ROD PUMPS

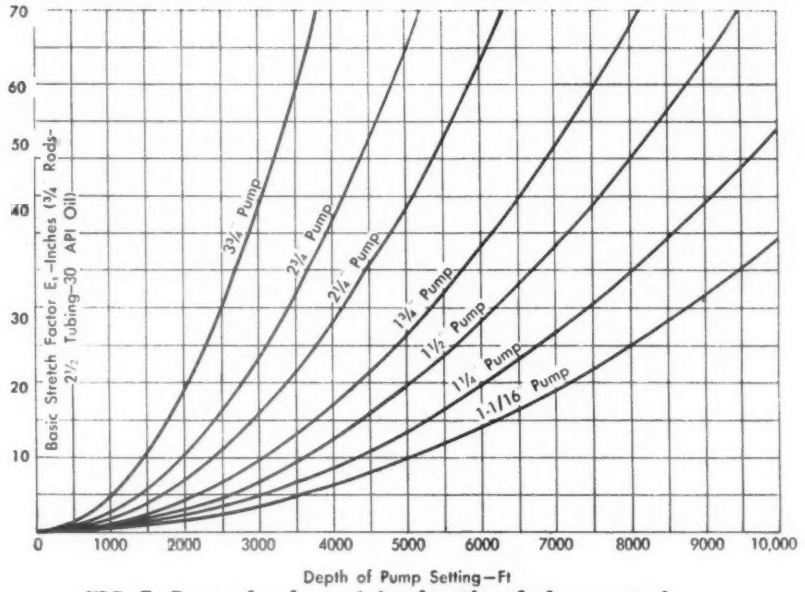


FIG. 7. Curves for determining lengths of plunger stroke.

● **Corrosion.** In some areas resistance to corrosion of the materials used in subsurface pumps is of major importance. A wide variety of alloy irons, steels, nonferrous alloys, and elements have been used to combat corrosive conditions in various districts. Some of the corrosive agents commonly found in various districts are hydrogen sulphide, salt waters containing sodium chloride, calcium chloride, magnesium chloride, and other salts, and in some cases carbon dioxide and oxygen have been reported. Although the corrosion problem cannot be covered adequately at this time, it is pointed out that many alloys having suitable resistance to corrosion are unsatisfactory because of insufficient hardness or resistance to wear.

Some materials are very satisfactory in some corrosive areas and entirely unsatisfactory in others. Many patented alloys that resist corrosive conditions and wear to a remarkable degree are used for various subsurface pump parts. Most of these are relatively expensive materials and it is necessary for the operator to determine experimentally whether they are economically justified in a particular area. Of the more common types of materials, alloy irons have given very good service for both barrel and plunger materials, and alloy irons are widely used at present both in one-piece and in sectional-liner type barrels and are giving good service even under rather severe salt water and sulphide corrosive conditions.

● **Effect of stretch of sucker rods and tubing.** Space will not permit a survey of the problems resulting from elasticity of sucker rod and tubing strings, and the practice of using tapered rod strings to effect savings in rod costs and to minimize rod stresses.

TABLE 3. Correction for rod and tubing combinations.

Rods, in.	Tubing, in.	Factor F_1
⅝	2	1.44
	2½	1.36
	3	1.30
¾	2	1.08
	2½	1.00
	3	0.941
⅞	2½	0.787
	3	0.729
	4	0.690
1	2½	0.648
	3	0.590
	4	0.551

Such a discussion would be a repetition of previously published information.[1, 2, 3] Figs. 7 and 8 show curves that can be used, with correction factors in Tables 3 and 4, and the accompanying explanations, to determine plunger strokes and pump displacements corresponding to various polished rod strokes for all common rod and tubing combinations, and densities of well fluids for seven commonly used pump bores. The following notes show methods for determining plunger strokes with uniform rod strings and with tapered strings. (See Appendix "A").

It is pointed out that these curves do not take account of dynamic effects, which vary with the pumping speed, and may result in "over-travel" of the plunger at high speeds. The displacements given by the curves, therefore, can be considered as minimum values to be expected. The curves were computed on the assumption that some grade of steel rods would be used and a value of 29×10^{-6} for the modulus of elasticity was assumed. If nonferrous rods are used an appropriate correction must be made for the modulus of the material.

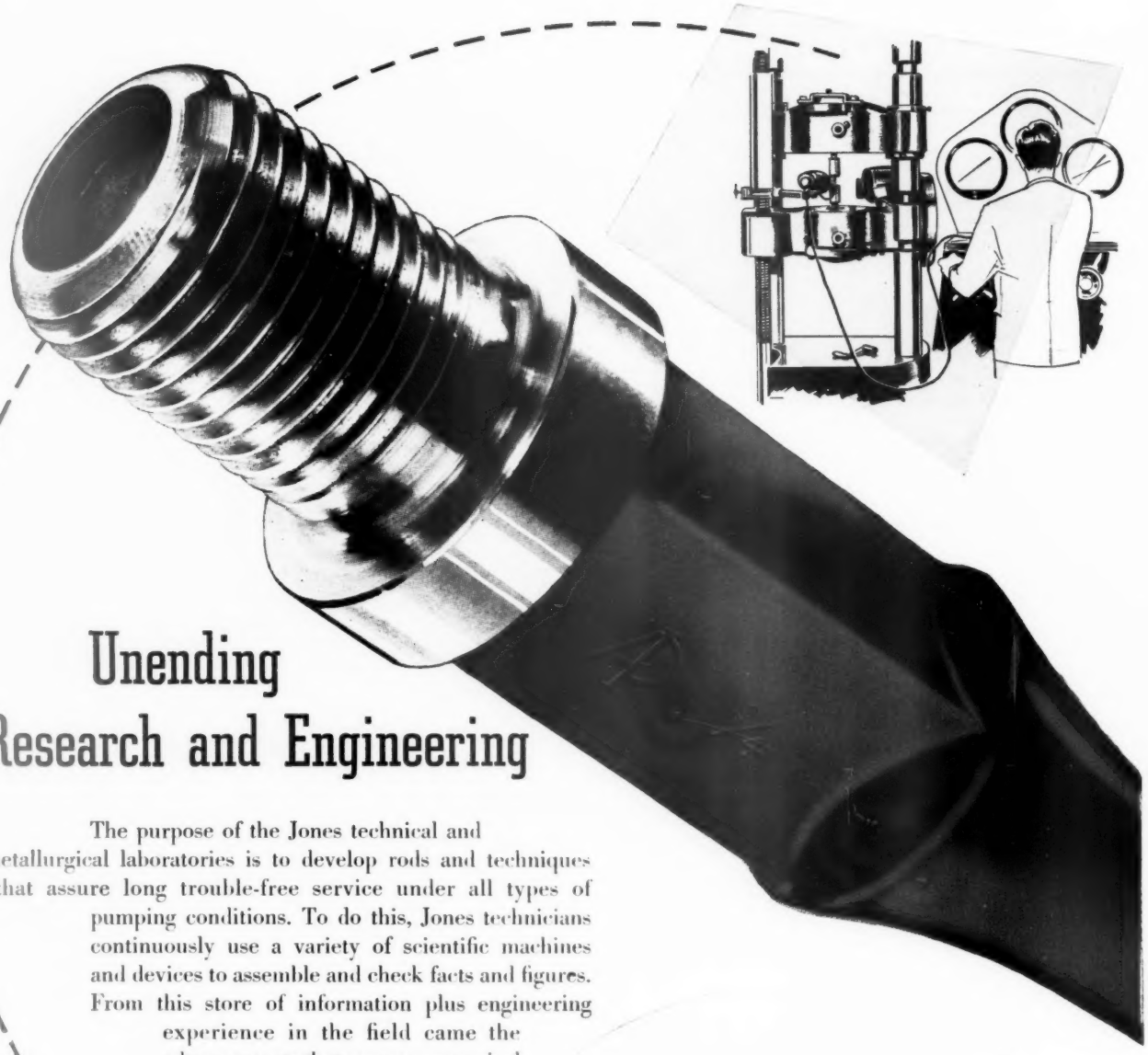
TABLE 4. Correction for gravity of fluid.

Sp. gr.	API gr.	Factor F_2
1.25		1.43
1.20		1.37
1.15		1.31
1.10		1.26
1.00	10	1.14
0.966	15	1.10
0.933	20	1.07
0.902	25	1.03
0.875	30	1.00
0.850	35	0.972
0.825	40	0.943
0.802	45	0.916
0.780	50	0.892

Before closing it should be emphasized that the largest pump does not always produce the most oil, with all other factors identical. For example, if we consider the relative displacements of 1¾-in., 1½-in., and 1¼-in. bore pumps when operated at a depth of 4000 ft. with a 36-in. polished rod stroke, at 20 spm, with ⅝-in. sucker rods and 2-in. tubing, producing oil of 30° API gravity, it is seen from Figs. 7 and 8 that a 1¾-in. bore pump will have net displacement of 84 bbl per day, a 1½-in. bore pump has a displacement of 126 bbl per day, and that of a 1¼-in. pump is 88 bbl per day. If maximum displacement is wanted, the 1½-in. pump is the logical selection, but if a displacement of 80 to 90 bbl per day is sufficient, the 1¼-in. pump is preferable to the 1½-in. or the 1¾-in. pumps because of the lighter load on the sucker rods and surface equipment.

Taken from the article "Factors to be considered in the selection of subsurface sucker-rod pumps," by R. L. Chenault, presented before The American Society of Mechanical Engineers, Houston, Texas, October 5-8, 1947, and published in *The Petroleum Engineer*, January, 1948, pages 132 to 150, inclusive.

Note: For Fig. 8, references, and Appendix "A" see sheet 6 P514.1.



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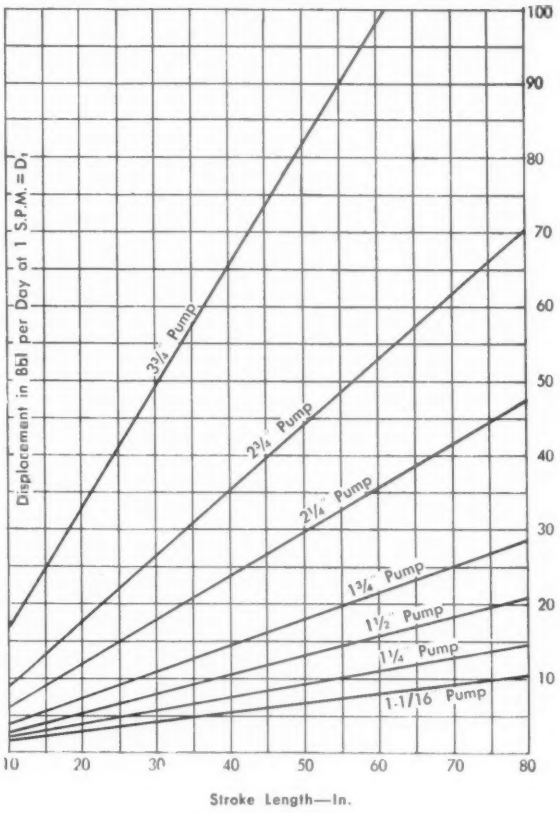

FIG. 8. Displacement of plunger pumps in barrels per 24-hr. day = $D_1 \times SPM$.

APPENDIX "A"

To determine pump plunger stroke with uniform rod strings:

$S_2 = S_1 - (E_1 \times F_1 \times F_2)$,

S_2 = actual plunger stroke,

S_1 = polished rod stroke,

E_1 = basic stretch factor from Fig. 7 for proper depth and pump size,

F_1 = correction factor from Table 3 for actual rod and tubing combination in well,

F_2 = correction factor from Table 4 for gravity of fluid.

To determine pump displacement:

1. Find value of D_1 (Fig. 8) corresponding to actual plunger stroke and pump size.
2. Displacement in bbl per day = $D_1 \times$ spm.

Example:

Well data

Depth to pump, 4500 ft.
Pump size, 1¾ in. ID.
Rods, ⅞ in.
Tubing, 2½ in.
Length of polished rod stroke, 48 in. = S_1.
Spm, 20.
API gravity, 25.

From Fig 7, E_1 for 1¾-in. pump at 4500 ft. = 21.6 in.

From Table 3, F_1 for ⅞-in. rods, 2½-in. tubing = 0.787.

From Table 4, F_2 for 25° API = 1.03.

Plunger stroke, $S_2 = 48 - (21.6 \times 0.787 \times 1.03) = 30.5$ in.

From Fig. 8, $D_1 = 10.8$ for 30.5-in. stroke, 1¾-in. pump.

Displacement = $10.8 \times 20 = 216$ bbl per day.

To determine plunger stroke with tapered sucker rod string:

Let A = length of ⅝-in. rods in string.
B = length of ¾-in. rods in string.
C = length of ⅞-in. rods in string.
D = length of 1-in. rods in string.
Y = total length of rod string.

Plunger stroke $S_2 = S_1 - E_1 F_2$

$$\left[(F_{1A} \times \frac{A}{Y}) + (F_{1B} \times \frac{B}{Y}) + (F_{1C} \times \frac{C}{Y}) + (F_{1D} \times \frac{D}{Y}) \right] \quad (3)$$

Where:

S_1 = polished rod stroke,

E_1 = basic stretch factor from Fig. 7 for depth and pump size,

F_{1A} = correction factor from Table 3 for ⅝-in. rods in tubing used,

F_{1B} = correction factor from Table 3 for ¾-in. rods in tubing used,

F_{1C} = correction factor from Table 3 for ⅞-in. rods in tubing used,

F_{1D} = correction factor from Table 3 for 1-in. rods in tubing used,

F_2 = correction factor from Table 4 for gravity of fluid.

Note that any particular term in parenthesis is used only if there is a rod size in the string corresponding to the letter (A, B, C, or D) appearing in this term. For example, if a tapered string consists only of ⅝-in. and ¾-in. rods equation (3) becomes:

$$S_2 = S_1 - E_1 F_2 \left[(F_{1A} \times \frac{A}{Y}) + (F_{1B} \times \frac{B}{Y}) \right]$$

Example:

Depth to pump, 4500 ft.
Pump size, 1¾ in.
Rods, 2400 ft, ¾ in. = B.
2100 ft, ⅞ in. = C.
Tubing, 2½ in.
Length of polished rod stroke, 48 in. = S_1.
API gravity, 25°.
From Fig. 7, E_1 for 1¾-in. pump at 4500 ft = 21.6 in.
From Table 3,
F_{1B} for ¾-in. rods and 2½-in. tubing = 1.00.
F_{1C} for ⅞-in. rods and 2½-in. tubing = 0.787.
From Table 4, F_2 for 25° API oil = 1.03.

Using ¾-in. and ⅞-in. rods, equation (3) becomes:

$$S_2 = S_1 - E_1 F_2 \left[(F_{1B} \times \frac{B}{Y}) + (F_{1C} \times \frac{C}{Y}) \right]$$

$$= 48 - (21.6 \times 1.03) \left[(1 \times \frac{2400}{4500} + (0.787 \times \frac{2100}{4500}) \right]$$

$$= 48 - 22.25 \ (0.533 + 0.367)$$
$$= 48 - (22.25 \times 0.90)$$
$$= 28\text{-in. plunger stroke.}$$

● References

1. E. A. Stephenson, "Stretch of Sucker Rods," *Oil and Gas Journal*, October 5, 1946.
2. E. N. Kemler, "The Desigh of Tapered Sucker Rod Strings," *The Oil Weekly*, August 2, 1943.
"How to Determine Proportions of Sucker Rod Strings," *The Oil Weekly*, August 7, 1944.
3. B. B. Wescott and C. N. Bowers, "Economical Selection of Sucker Rods," *AIME Transactions*, Vol. 114, 1935.

Taken from the article "Factors to be considered in the selection of subsurface sucker-rod pumps," by R. L. Chenault, presented before The American Society of Mechanical Engineers, Houston, Texas, October 5-8, 1947, and published in *The Petroleum Engineer*, January, 1948, pages 132 to 150, inclusive.

Note: For Tables 3 and 4 and Fig. 7, see sheet 5, P514.1.

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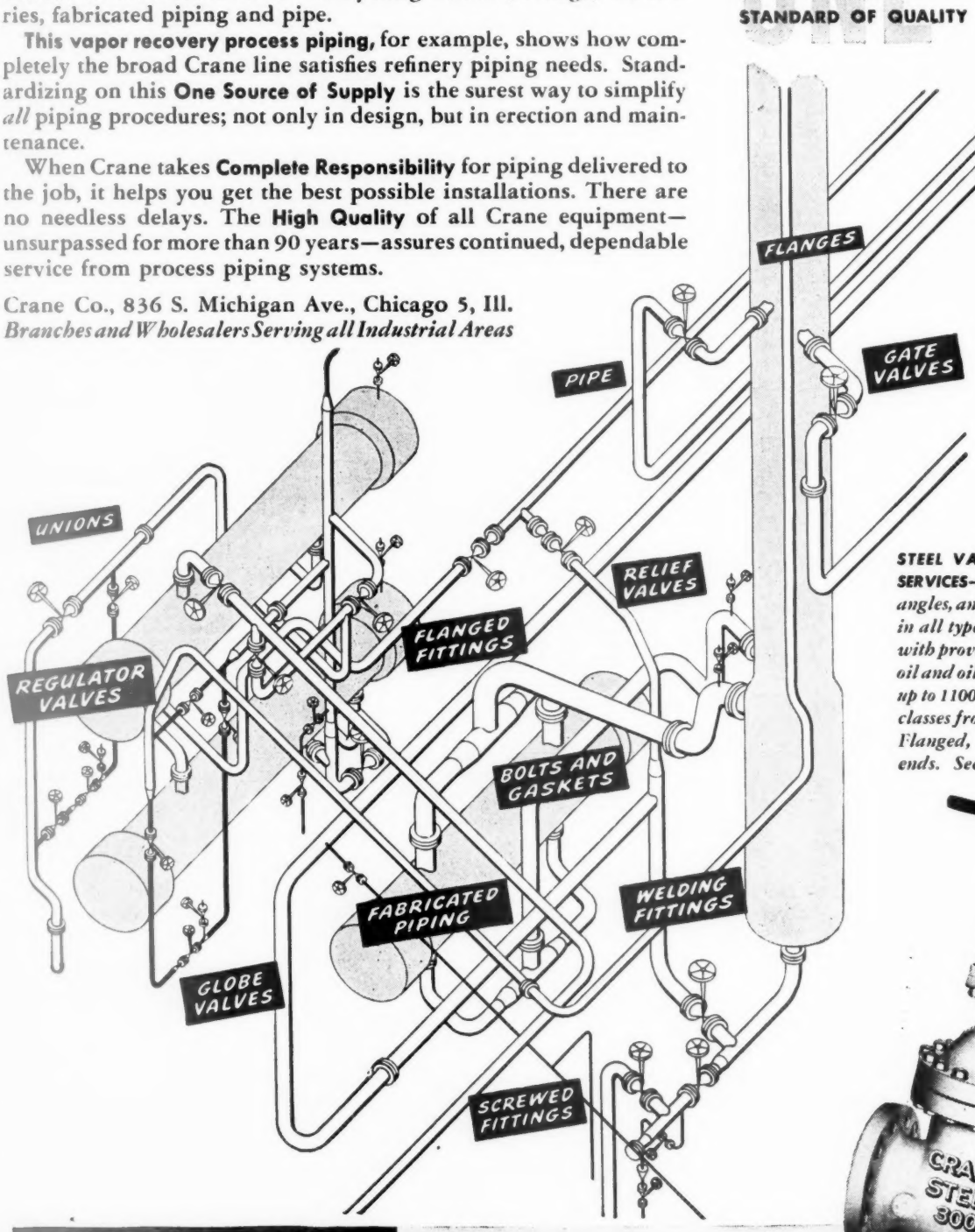

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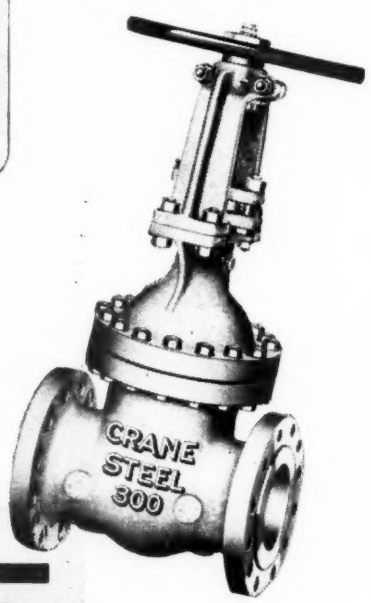

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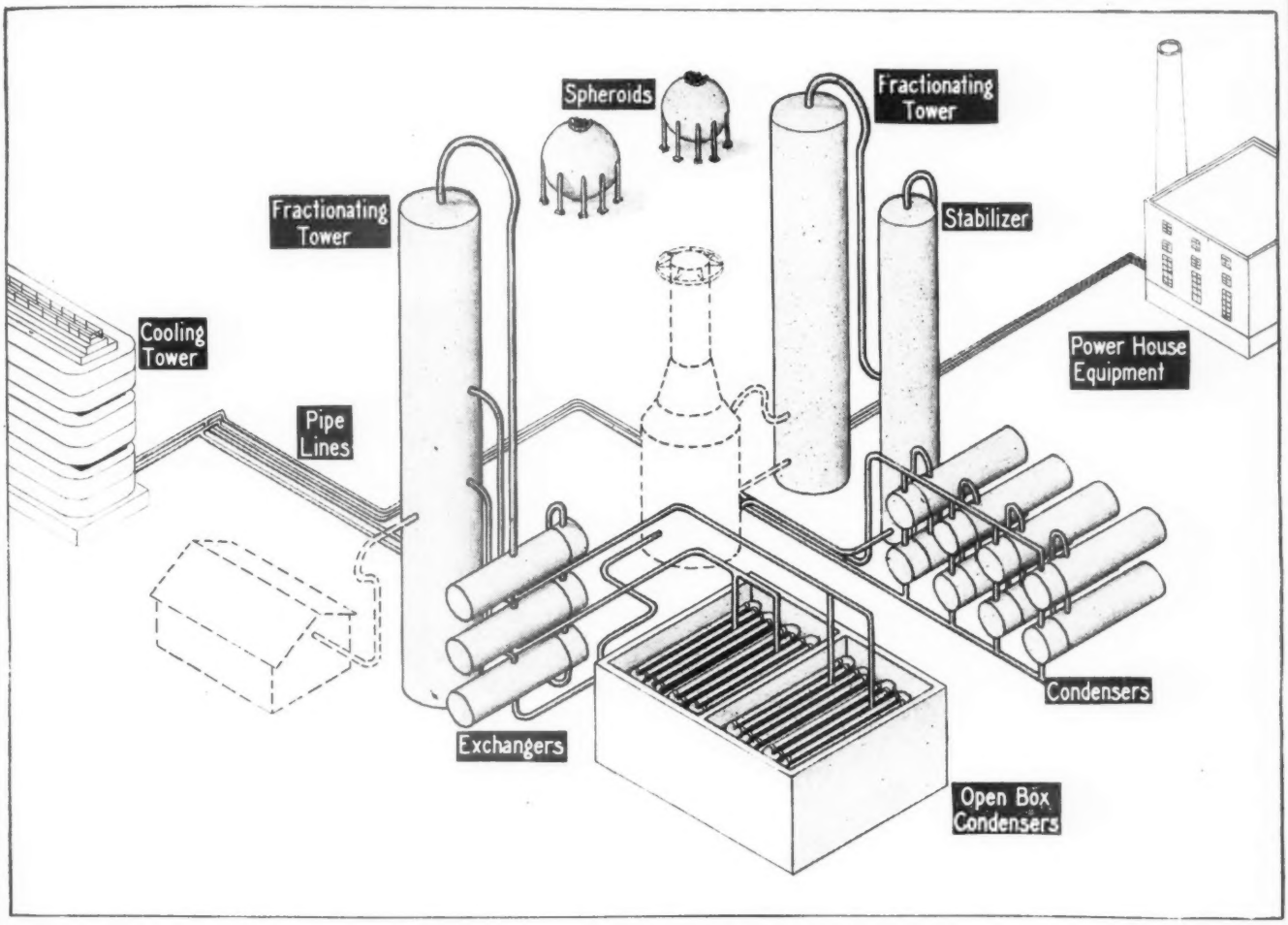

FIG. 1. Refinery equipment that can be chemically cleaned.

Chemical cleaning has been successfully applied to practically every type of steam raising, heat exchange, transfer and storage in all refinery divisions. Fig. 1 illustrates the divisions and types of equipment in a refinery that can be chemically cleaned. In the power house the equipment consists of water treating units, filters, pumps, transfer lines, engine jackets, heaters, economizers, boilers, superheaters, and related units. Refinery cooling water systems with their coils, collecting and distributing lines are particularly adapted to chemical cleaning as it eliminates dismantling. Open box condensers, tube and shell units, and practically all water handling equipment can be chemically cleaned. In the process equipment of a refinery, towers of all types are quickly and effectively cleaned as well as tube and shell units, lines and storage facilities.

Chemical cleaning must be based upon a consideration of three factors. These are: (1) The deposit to be removed; (2) the solvent to be used, and (3) the unit to be cleaned.

● **Deposits encountered.** The deposits encountered in refinery equipment fall into three classes. These are inorganic materials, organic materials, and mixtures of both. Inorganic deposits are associated with equipment handling water and are laid down either by deposition from the water or by corrosion of the metal, or both. Organic deposits are encountered in the process sides of refinery equipment. They are formed by the decomposition and polymerization of petroleum hydrocarbons on the contact surfaces of the units. Mixtures of organic and inorganic deposits also are encountered in the process sides of refinery equipment with the inorganic portions generally composed of iron oxides and sulphides, copper oxides and sulphides, and other metallic salts.

The nature of the deposit, inorganic, organic or mixtures of both, dictates the type of sovent adaptable to removing it. The solvent associated with inorganic scale removal is hydrochloric acid in concentrations of 5 to 15 per cent by weight. Various modifications of the acid may be obtained by the addition of wetting and emulsifying agents and intensifiers or catalysts. Solvents associated with the removal of scale deposited from process materials include hydrochloric acid, alkaline solutions, detergents, hydrocarbon solvents, chlorinated hydrocarbons, and oxidizing solutions.

As described above chemical cleaning is adaptable to the equipment in practically every division of the refinery. The unit to be cleaned enters into the calculations concerning chemical cleaning as its design, its size in respect to surface area and volume, the metals from which it is fabricated and the service it is in all must be considered. Each of these factors contributes to the type, concentration and amount of solvent and the conditions under which it ban be applied.

● **Water side deposits.** A sample of the scale must be obtained from the unit to be cleaned that is representative of the bulk of the scale. The location of the scale sampled and the manner of sampling are important as the sample must represent the scale deposit down to the bare metal. This sample then may be analyzed by the most convenient methods available. Simple qualitative chemical tests are sufficient to identify the deposit as to carbonates, phosphates, oxides, sulphates or silicates.

NOTE: See sheet 3 for references. Taken from the exclusive article, "Chemical Cleaning in the Refinery," by C. H. Groom, published in *The Petroleum Engineer*, April, 1948, pages 110 to 114, inclusive.

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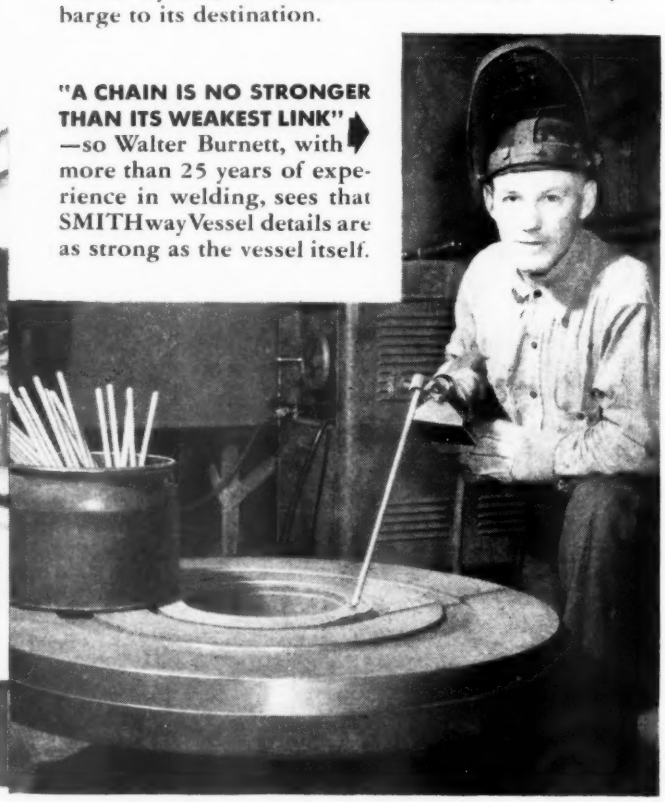

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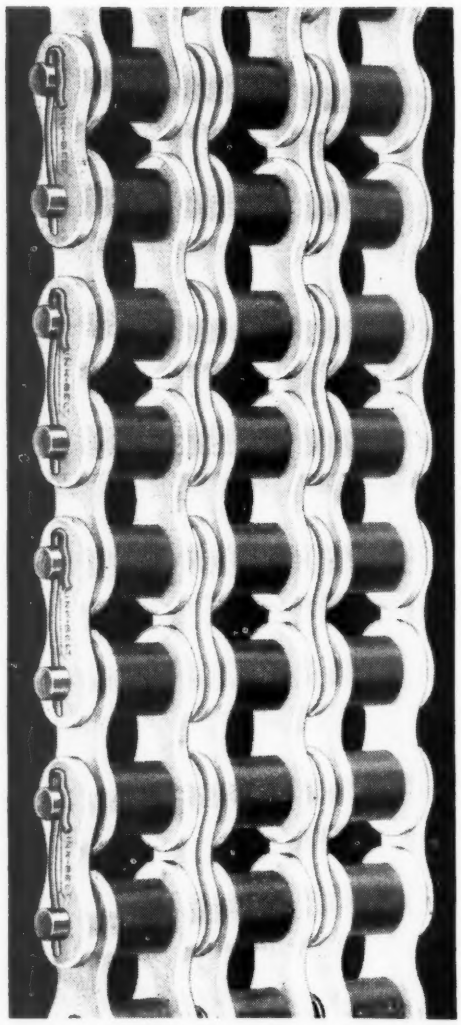

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					10 3/4					11 3/4					13 3/8					16					18 5/8		20		21 1/2		24 1/2	
Drill pipe size (OD in.)	Inside diameter of tool joint (ID in.)	Internal area of tool joint, area "P"	OD of stabilizer on pipe (in.)	Area of stabilizer on pipe, area "C"	Wt. 55.50 ID 9.760 Int area 74.82 sq in. "D"	Wt. 51 ID 9.850 Int area 76.20 sq in. "D"	Wt. 45.50 ID 9.950 Int area 77.76 sq in. "D"	Wt. 40.50 ID 10.050 Int area 79.33 sq in. "D"	Wt. 32.75 ID 10.192 Int area 81.58 sq in. "D"	Wt. 60 ID 10.772 Int area 91.13 sq in. "D"	Wt. 54 ID 10.880 Int area 92.97 sq in. "D"	Wt. 47 ID 11.000 Int area 95.03 sq in. "D"	Wt. 42 ID 11.084 Int area 96.49 sq in. "D"	Wt. 38 ID 11.150 Int area 97.64 sq in. "D"	Wt. 72 ID 12.347 Int area 119.7 sq in. "D"	Wt. 68 ID 12.415 Int area 121.1 sq in. "D"	Wt. 61 ID 12.515 Int area 123.0 sq in. "D"	Wt. 54.50 ID 12.615 Int area 125.0 sq in. "D"	Wt. 48 ID 12.715 Int area 127.0 sq in. "D"	Wt. 84 ID 15.000 Int area 177.0 sq in. "D"	Wt. 75 ID 15.125 Int area 179.7 sq in. "D"	Wt. 65 ID 15.250 Int area 182.7 sq in. "D"	Wt. 55 ID 15.375 Int area 185.7 sq in. "D"	Wt. 96.50 ID 17.655 Int area 244.81 sq in. "D"	Wt. 78 ID 17.855 Int area 250.39 sq in. "D"	Wt. 94 ID 19.124 Int area 287.2 sq in. "D"	Wt. 114 ID 20.510 Int area 330.39 sq in. "D"	Wt. 92.50 ID 20.710 Int area 336.86 sq in. "D"	Wt. 113 ID 23.650 Int area 439.29 sq in. "D"	Wt. 100.50 ID 23.750 Int area 443.02 sq in. "D"
Clearance ratio = area "D" minus area "C" divided by area "B"																																
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			6 5/16	31.30	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
2 7/8	2.125	3.55	7 5/16	42.00	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
			8 1/4	53.46	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
			6 11/16	35.13	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
3 1/2	2.688	5.67	7 5/8	45.66	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
			8 1/2	56.72	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
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			9 7/8	76.59	x	x	x	x	x	1.3	1.5	1.7	1.8	1.9	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
			11 5/16	98.30	x	x	x	x	x	x	x	x	x	x	1.9	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
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			8 5/8	58.43	1.5	1.6	1.8	1.9	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
5	3.750	11.05	8 3/4	60.13	1.3	1.5	1.6	1.7	1.9	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
			9	63.62	x	x	1.3	1.4	1.6	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
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			10 5/16	81.51	x	x	x	x	x	x	x	1.2	1.4	1.5	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
			11 5/16	102.74	x	x	x	x	x	x	x	x	x	x	1.5	1.7	1.8	2.0	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
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5 9/16	4.000	12.57	9 3/8	65.40	x	x	x	x	1.3	o	o	o	o	o																o	o	o
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			11 11/16	107.28	x	x	x	x	x	x	x	x	x	x	x	x	1.3	1.4	1.6	o	o	o	o	o	o	o	o	o	o	o	o	o
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			8 5/8	55.09	x	x	1.2	1.2	1.3	1.8	1.9	2.0	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
			9 3/8	65.40	x	x	x	x	x	1.3	1.4	1.5	1.6	1.6	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
			9 7/16	75.62	x	x	x	x	x	x	x	x	x	x	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
			9 15/16	77.56	x	x	x	x	x	x	x	x	x	x	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
6 5/8	5.000	19.64	10 5/16	83.53	x	x	x	x	x	x	x	x	x	x	1.8	1.9	2.0	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
			10 5/8	88.66	x	x	x	x	x	x	x	x	x	x	1.6	1.6	1.7	1.8	2.0	o	o	o	o	o	o	o	o	o	o	o	o	o	o
			11 7/8	110.75	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	o	o	o	o	o	o	o	o	o	o	o	o	o
			13 11/16	147.14	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1.5	1.7	1.8	2.0	o	o	o	o	o	o	o	o	o
			15 3/4	194.83	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	o	o	o	o	o	o	o	o	o
			18 11/16	274.28	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	o	o	o	o	o	o	o

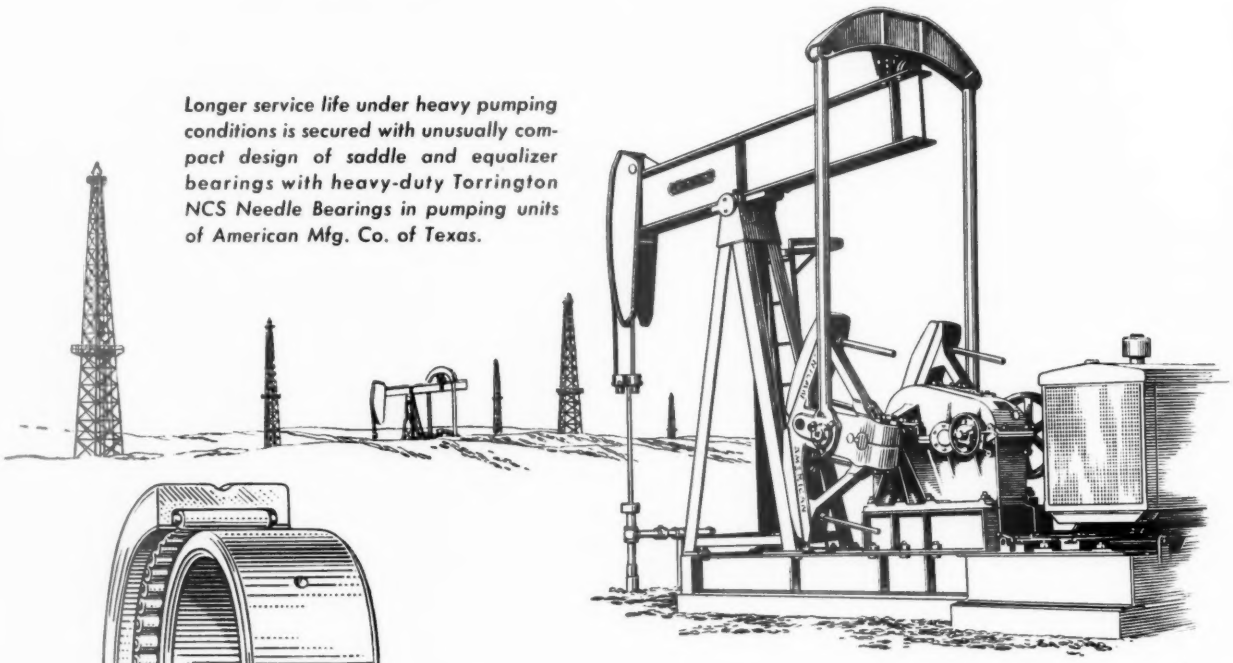
x—Clearance ratios less than 1.0.
1.4—Clearance ratios shown between 1.0 and 2.0.
o—Ample clearance ratios.

Note: 1. All tool joint inside diameters are given for A.P.I. internal flush except 5-9/16 and 6⅝ which are A.P.I. full hole sizes.

—Courtesy Patterson-Ballagh Division of Byron Jackson Company.

How to "Saddle" Pumping Units to Carry Heavy Loads Easily

Longer service life under heavy pumping conditions is secured with unusually compact design of saddle and equalizer bearings with heavy-duty Torrington NCS Needle Bearings in pumping units of American Mfg. Co. of Texas.



. . . in saddle and equalizer applications, Torrington NCS Needle Bearings carry heavier loads in less space a longer time.

Torrington Type NCS Needle Bearings reduce friction and wear in saddle, equalizer and pitman locations in pumping units, assuring long service life under heavy pumping loads.

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In pumping units, slush pumps, rotary tables, draw works, swivels, crown blocks, traveling blocks and drilling rigs, Torrington Bearings of all types have proved their ability to carry heavy loads. Torrington's engineers have had years of experience designing, building and applying anti-friction bearings for oil field equipment. Consult them on your next friction problem. Call or write the nearest Torrington office.

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FORMULAS FOR THE PREPARATION OF TANK GAUGE TABLES

● **Spherical zone formula.** This is a general formula to obtain the volume of any part of a semisphere bounded by one or two intersecting horizontal planes, parallel to the plane passing through the center of the sphere. A typical application of this formula would be for spherical tanks such as the Hortonsphere or for vertical and horizontal cylindrical tanks with hemispherical heads.

● **Conical zone formula.** This is a general formula for calculating the volume of any part of a conical section in a vertical position bounded by one or two intersecting horizontal planes, parallel to a plane passing through the apex of the cone. An application of this formula would be for vertical cylindrical tanks with conical ends.

● **Elliptical zone formula.** For horizontal cylindrical tanks with elliptical ends, this is a general formula for determining the volume of any part of a spheroid bounded by one or two intersecting horizontal planes, parallel to a plane passing through the center perpendicular to the axis of revolution.

● **Elliptical zone formula.** For vertical cylindrical tanks with elliptical ends, a general formula for the volume of any part of a spheroid bounded by one or two intersecting horizontal planes, parallel to a plane passing through the center perpendicular to the axis of revolution.

In the following examples of application small measurements were used and consequently the calculations for the various constants were carried out to only four decimal places but for complete accuracy on large tanks the constants should be carried out to eight or ten places depending upon the calculating machine used. Also in the spherical zone formula on large tanks it may be found necessary to change the radius due to the construction of the tank and new constants will have to be calculated when this occurs.

The general formulas were developed by the use of calculus and the derivation will not be given; however, in the computation of volumes in a series of increments such as this the general formula can be converted to such a form as to allow use of arithmetic progression of the upper and lower limits of this increment, permitting the series of volumes to be easily computed by use of a calculating machine. Following are examples of the four general formulae:

Spherical zone formula:

$$V_1 = \pi GF\left(R^2 \frac{G^2}{3} - AB\right) \quad . \quad . \quad (1)$$

In which:

V_1 = the volume of the spherical segment between limits A and B.

A = the radial distance from the center of the sphere to the closer intersecting horizontal plane.

B = the radial distance from the center of the sphere to the more distant intersecting horizontal plane.

R = the radius of the sphere.

G = the distance between the limits A and B.

F = the volume factor (as 7.4805, the number of U. S. gal. per cu ft).

In the preparation of gauge tables for tanks, it is necessary to obtain the volumes for small increments such as 1, ½, or ¼ in., in which case the factor G in formula (1) would become 1, ½, or ¼ in. expressed in the common unit. Formula (1) can be further simplified so that the volumes of a series of increments can be obtained very readily by the use of a calculating machine.

Thus, the volume of any small section, M sections from the center of the sphere, becomes:

$$V_M = \pi GF\left(R^2 - \frac{G^2}{3} - AB\right)$$

$$= \pi GF\left[R^2 - \frac{G^2}{3} - (M-1)\,G \times MG\right]$$

Where $(M-1)G$ is substituted for A and MG is substituted for B, M being the number of sections (of depth G) from the center of the sphere. Simplifying:

$$V_M = \pi GF\left[R^2 - \frac{G^2}{3} - (M^2 - M)G^2\right]$$

Let:

$$K_1 = \pi GFR^2 - \frac{\pi G^3 F}{3} \quad . \quad . \quad . \quad (2)$$

$$K_2 = 2\pi G^3 F \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Then:

$$V_M = K_1 - \frac{M^2 - M}{2} K_2 \quad . \quad . \quad (4)$$

The volume of the $(M+1)^{th}$ section will be:

$$V_{M+1} = K_1 - \frac{(M+1)^2 - (M+1)}{2} K_2$$

$$= K_1 - \frac{M^2 + M}{2} K_2$$

$$V_M - V_{M+1} = K_1 - \frac{M^2 - M}{2} K_2 - K_1$$

$$+ \frac{M^2 + M}{2} K_2 = MK_2$$

From which:

$$V_M = V_{M+1} + MK_2 \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Formulae (4) and (5) offer a very simple means of computing the volumes of a series of increments or sections of a semisphere. By using formula (4) to obtain the volume of any particular section M, then formula (5) can be set up in a calculating machine so that the volumes of a series of sections approaching the center of the sphere can easily be computed.

For example in Fig. 1, if:

R = 1.0 ft

G = 1 in. = 0.083333 ft

F = 7.4805 gal per cu ft.

Find the individual and cumulative volumes of the twelve 1-in. sections.

Solution:

Using formula (2): $K_1 = 1.9539$

Using formula (3): $K_2 = 0.027200$.

Substituting in formula (4), the volume of the 12th section from the center of the sphere is:

$$V_{12} = 1.9539 - \frac{12^2 - 12}{2} \times 0.0272$$

$$= 0.159 \text{ gal.}$$

Then substituting in formula (5), the volume of the 11th section is:

$$V_{11} = V_{12} + 11K_2$$

$$= 0.159 + 11 \times 0.027200$$

In the application of formula (5) to a calculating machine, the value of V_{12} is placed in the lower dial, and K_2 is placed in the keyboard, making sure that the decimal point is placed correctly. Then multiply by each decreasing value of M, as 11, 10, 9, etc., for the volume of each particular section M. During the series of calculations, the lower dial and the keyboard are not cleared at any time.

The complete set of calculations for the twelve 1-in. sections is as follows:

Section number	Volume of section, gal	Cumulative volumes, gal
12	0.159	0.159
11	0.458	0.617
10	0.730	1.347
9	0.975	2.322
8	1.193	3.515
7	1.383	4.898
6	1.546	6.444
5	1.682	8.126
4	1.791	9.917
3	1.873	11.790
2	1.927	13.717
1	1.954	15.671

As a check for the total volume, formula (1) is applicable:

$$\text{Volume} = \pi GF\left(R^2 - \frac{G^2}{3} - AB\right)$$

In this case:

A = 0 and B = R

R = 1 ft.

G = 1 ft.

F = 7.4805 gal per cu ft.

Therefore: Volume = 15.667 gal.

NOTE: See sheet 2 for Fig. 1. Taken from the exclusive article "Volume Determination of Tanks," by T. F. Phillians, published in *The Petroleum Engineer*, March, 1948, pages 174 to 178, inclusive.

Give New Life to Worn Parts

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This automatic process saves time and money—welding is fast—parts are returned to service quickly—new surface is often superior to original—

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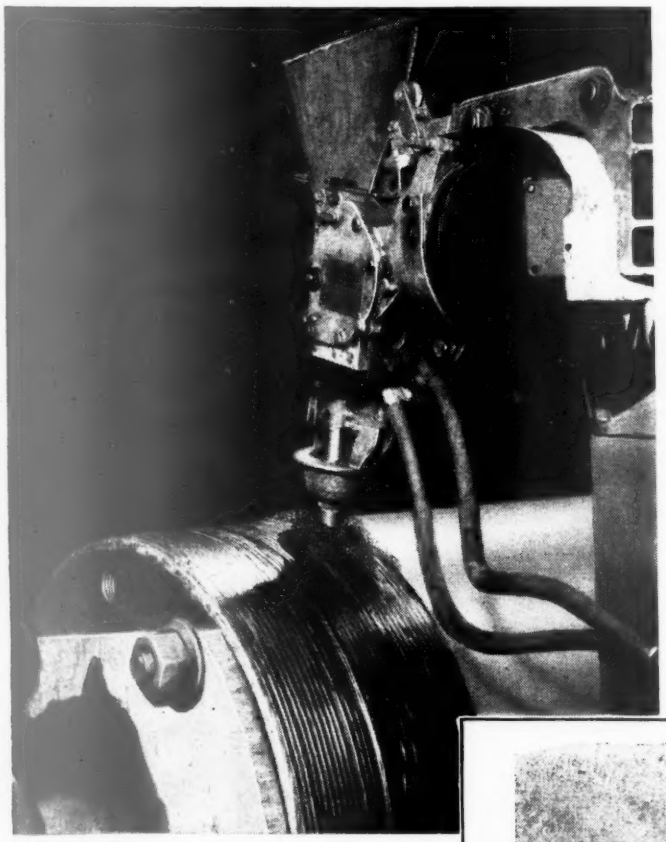

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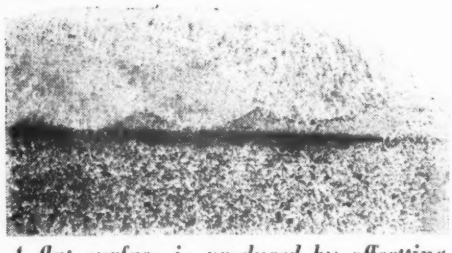

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FORMULAS FOR THE PREPARATION OF TANK GAUGE TABLES

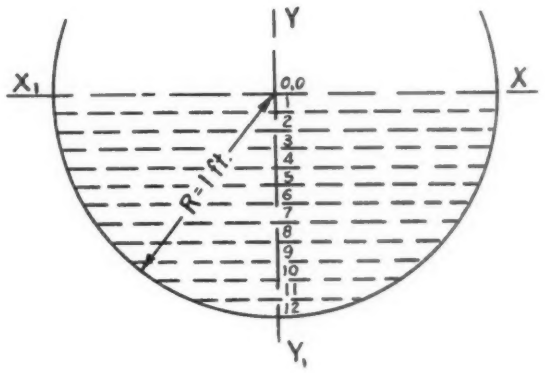


FIG. 1.

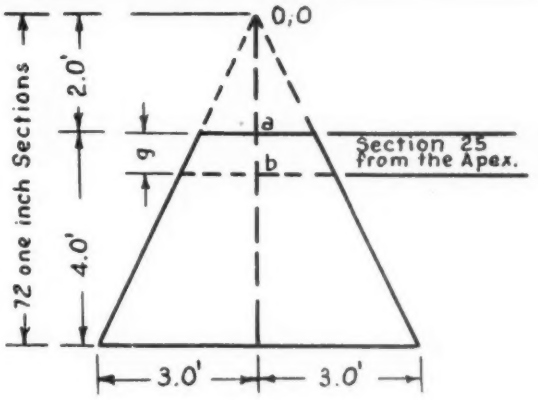


FIG. 2.

Conical zone formula:

$$V_1 = \frac{\pi F}{3N^2}(3GAB+G^3) \quad . \quad . \quad . \quad (6)$$

In which:

V_1 = the volume of the conical segment between limits A and B,

A = the distance from the apex of the cone to the closer intersecting horizontal plane,

B = the distance from the apex of the zone to the more distant intersecting horizontal plane,

N = the slope of the cone (the height of the cone divided by the radius of the base),

G = the distance between the limits A and B,

F = the volume factor (as 7.4805, the number of U. S. gal per cu ft).

Thus, the volume of any small section M from the apex of the cone becomes:

$$V_M = \frac{\pi F}{N^2}(GAB)+\frac{\pi FG^3}{3N^2} - \frac{\pi F}{N^2}\left[G\times(M-1)G\times(MG)\right] + \frac{\pi FG^3}{3N^2}$$

When (M—1)G is substituted for A and (MG) is substituted for B, M being taken as the number of G sections from the apex of the cone:

$$V_M = \frac{2\pi FG^3}{N^2}\left(\frac{M^2-M}{2}\right)+\frac{\pi FG^3}{3N^2}$$

$$K_3 = \frac{2\pi FG^3}{N^2} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Then:

$$V_M = K_3\frac{(M^2-M)}{2}+\frac{K_3}{6} \quad . \quad . \quad (8)$$

The volume of the $(M+1)^{th}$ section will be:

$$V_{M+1} = K_3\frac{(M+1)^2-(M+1)}{2}+\frac{K_3}{6} - K_3\frac{M^2+M}{2}+\frac{K_3}{6}$$

$$V_{M+1}-V_M = K_3\left(\frac{M^2+M}{2}\right)+\frac{K_3}{6} - K_3\left(\frac{M^2-M}{2}\right)+\frac{K_3}{6}-MK_3$$

From which:

$$V_{M+1} = V_M+MK_3 \quad . \quad . \quad . \quad . \quad . \quad (9)$$

The application of formulas (8) and (9) is similar to that of formulas (4) and (5).

For example, in Fig. 2, if:

G=1 in.=0.083333 ft,

N=2

F=7.4805 gal per cu ft.

Find the individual and cumulative volumes of the 48 1-in. sections from 2 to 6 ft below the apex.

Solution: From formula (7):

K_3=0.0068.

Substituting in formula (8), the volume of the 25th section from the apex is:

$$V_{25} = 0.0068\times\frac{25^2-25}{2}+0.001$$

=2.041 gal.

Then substituting in formula (9), the volume of section 26 is:

$V_{26} = V_{25}+25\ K_3$

=2.041+25×0.0068

=2.211 gal.

In applying formula (9) to a calculating machine, the value V_{25} is placed in the lower dial and K_3 is placed on the keyboard. Then multiply by each increasing value of M, as 25, 26, 27, etc., for the necessary volumes.

The complete set of calculations for the 48 1-in. sections is as follows:

Section number	Volume of section, gal	Cumulative volumes, gal
25	2.041	2.041
26	2.211	4.252
27	2.388	6.640
28	2.572	9.212
29	2.762	11.974
30	2.959	14.933
31	3.163	18.096
32	3.374	21.470
33	3.592	25.062
34	3.816	28.878
35	4.047	32.925
36	4.285	37.210
37	4.530	41.740
38	4.782	46.522
39	5.040	51.562
40	5.305	56.867
41	5.577	62.444
42	5.856	68.300
43	6.142	74.442
44	6.434	80.876
45	6.733	87.609
46	7.039	94.648
47	7.352	102.000
48	7.672	109.672
49	7.998	117.670
50	8.331	126.001
51	8.671	134.672
52	9.018	143.690
53	9.372	153.062
54	9.732	162.794
55	10.099	172.893
56	10.473	183.366
57	10.854	194.220
58	11.242	205.462
59	11.636	217.098
60	12.037	229.135
61	12.445	241.580
62	12.860	254.440
63	13.282	267.722
64	13.710	281.432
65	14.145	295.577
66	14.587	310.164
67	15.036	325.200
68	15.492	340.692
69	15.954	356.646
70	16.423	373.069
71	16.899	389.968
72	17.382	407.350

As a check for the total volume using formula (6):

$$\text{Volume} = \frac{\pi F}{3N^2}(3\ GAB+G^3)$$

Where:

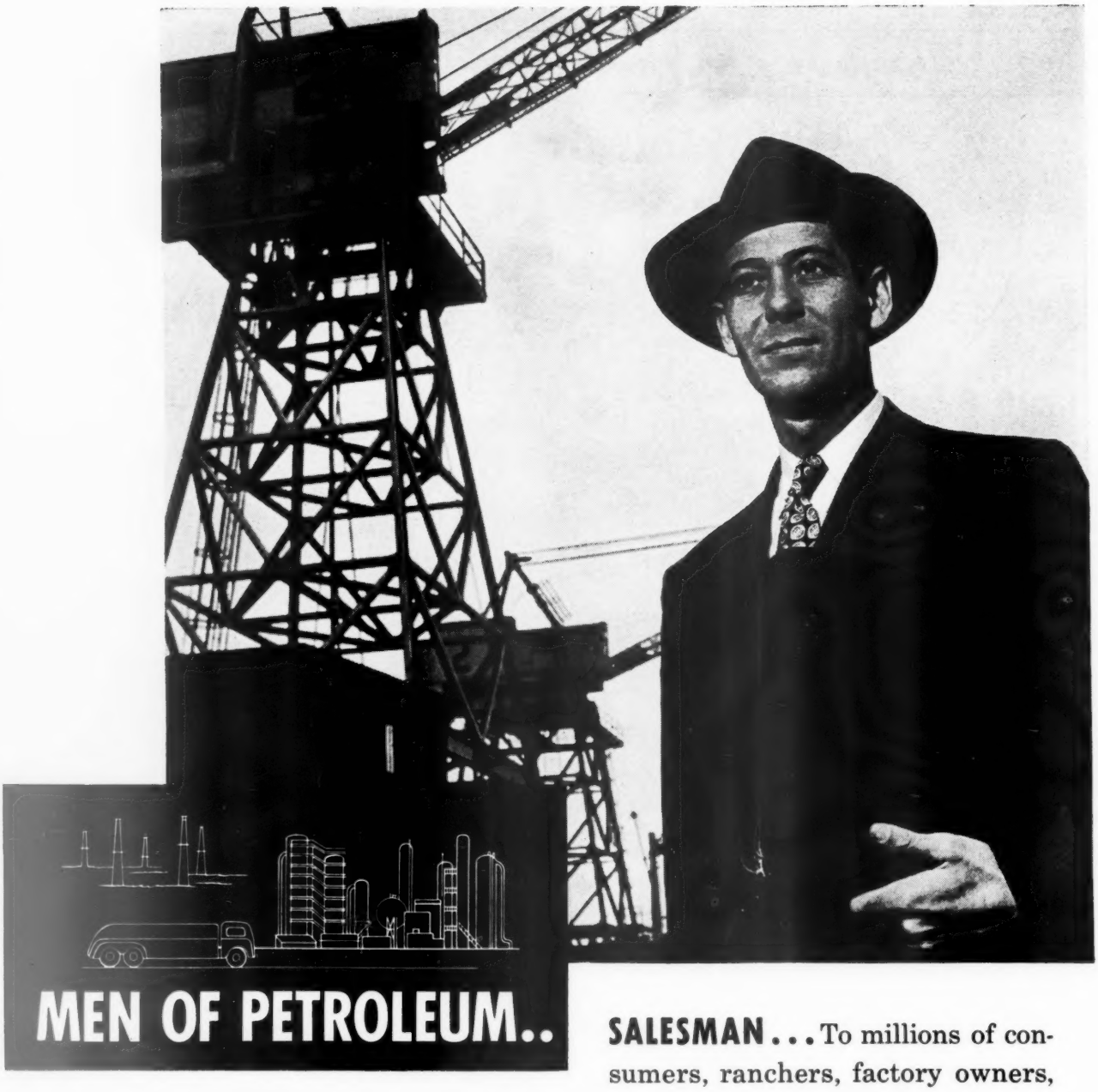
A=2.0 ft

B=6.0 ft

G=4.0 ft.

Volume=407.347 gal.

NOTE: See sheet 1 for spherical zone formula. Taken from the exclusive article "Volume Determination of Tanks," by T. F. Phillians, published in *The Petroleum Engineer*, March, 1948, pages 174 to 178, inclusive.



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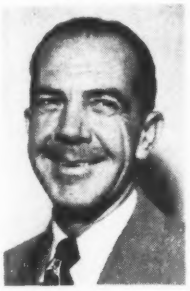
STANDARD OIL COMPANY OF CALIFORNIA

BJ transfers five

The Oil Tool Division of Byron Jackson Co., Los Angeles, California, announces the following new assignments for sales personnel: Robert B. Kirk from sales training to export office, Los Angeles; John P. Kirby from Los Angeles sales of West Texas and New Mexico sales territory; Dick T. Clardy from Los Angeles sales to West Texas and New Mexico sales territory; Harry R. Collins, Jr., from sales training to Los Angeles Basin sales territory, and George D. Dwyer from Los Angeles Basin sales territory to Wyoming sales territory.

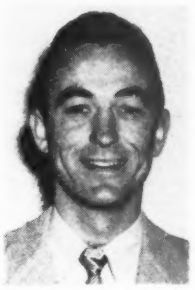


R. B. Kirk

J. P. Kirby

D. T. Clardy

H. R. Collins, Jr.



G. D. Dwyer

Kerotest new president

Parker F. Wilson, well known steel executive, was elected president and director of the Kerotest Manufacturing Company, Pittsburgh, at a recent meeting of the board of directors. Former president Walter G. Swaney was named vice-chairman of the board.

Parker Wilson

A familiar figure in steel circles for more than 20 years, Wilson has served in various executive capacities with Otis Steel Company, Wheeling Steel Corporation, and more recently as president of Pittsburgh Steel Foundry Corporation.

Expansion program

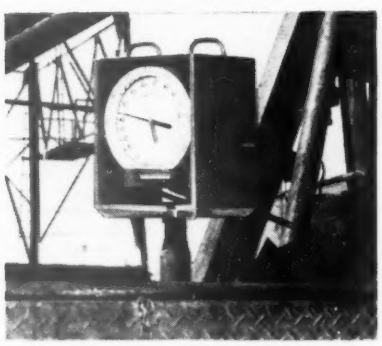
A three-year program for expansion of development and production operations has been started by Brown division of Minneapolis-Honeywell Regulator Company as the second step in its $2,500,000 physical expansion. The first part of the three-year program has resulted in the hiring of 40 newly graduated engineers.

"The three-year schedule," said Henry F. Dever, president of Brown Instrument Company, Philadelphia, "not only means a necessary increase in our engineering staff but in several ways contributes toward providing newly hired graduates with a clearer and earlier insight into our manufacturing methods and procedures. It speeds up their becoming well acquainted with new and modern industrial processing for which our devices are used."

The plan, Dever pointed out, includes speedy indoctrination of the new engineers who are being assigned to various engineering departments. It means an immediate expansion of the company's development engineering by 30 per cent and by 10 per cent in application, industrial, and general engineering.

After initial indoctrination in company departmental operations, each

NOW ...all types of small rigs can have the same weight indicator accuracy, sensitivity, ruggedness and dependability as a 15,000' rig with MARTIN-DECKER production model WEIGHT INDICATORS



A Portable Model Clipper Sealtite installed on an Indeco H 40 Rig. Portable models are ideal for any small space. Dimensions 14" x 17" x 12". Note convenience of handles. Can be installed permanently if desired.

A MARTIN-DECKER Production Model Weight Indicator can be placed anywhere you want it, at the brake, in front of the driller, over next to the line permanently attached to the mast, without danger of damage from dead line vibration or whip, and with it you can read your loads with precision in pounds. Equipped with super sensitive vernier for maximum sensitivity and readability.

PRODUCTION MODEL CLIPPER SEALTITES OFFER THESE OUTSTANDING ADVANTAGES

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SENSITIVE: Dependable, sensitivity adjustors permit just the right degree of sensitivity and readability. The Vernier Weight Indicator with 6 to 1 ratio is included and is available for fishing jobs, etc.

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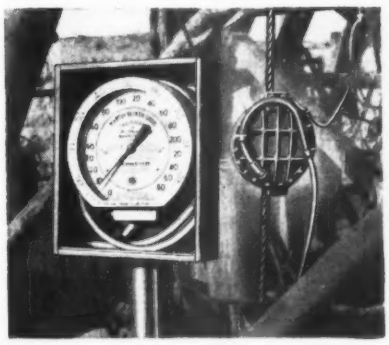

The Clipper Sealtite above is permanently installed on a Hopper Blitz trailer mounted rig. Lowering the mast and moving in no way interferes with this installation.

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graduate is being given a course in development, manufacture, and application of industrial measuring, indicating, and controlling instruments.

The first step of the $2,500,000 expansion program, construction of a new building, is well under way, Dever said.

New chemical section

The Engineering and Construction Division of Koppers Company, Inc., Pittsburgh, Pennsylvania, has set up a new chemical section to supervise and coordinate engineering and construction work on contracts procured for the erection of plants to produce oxygen, synthetic fuels, and certain types of chemicals, it is announced by Joseph Becker, vice president.

Heading up the new section will be T. M. Osborne, who has been project manager on Koppers' contract to build a $4,500,000 synthetic liquid fuels plant for the government at Louisiana, Missouri.

The new section will have general responsibility for all contracts to build oxygen plants and synthetic liquid fuels plants, as well as for contracts for chemical plants which are not directly associated with coke oven and steel plants. In addition to the plant being built at Louisiana, Missouri, the Koppers Engineering and Construction Division has virtually completed a tonnage oxygen plant at Johnstown, Pennsylvania.

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HERE IS ANOTHER Transite* salt water disposal line that will soon be saving money. Frequent pipe replacements will be eliminated because Transite Pipe, made of asbestos and cement combined by a special process, fights corrosion two ways. It resists the corrosive action of salt water on the *inside*... corrosive soil on the *outside*.

You get other advantages, too, with Transite Pipe. Light in weight, it is easy to handle. Most sizes can be unloaded and lowered into the trench without the use of mechanical handling equipment. And Transite's factory-made Simplex Couplings speed assembly . . . provide *tight* yet *flexible* joints that permit laying the pipe around curves without special fittings.

For further details, address Johns-Manville, Box 290, New York 16, N. Y.

JOHNS-MANVILLE PRODUCTS

*Reg. U. S. Pat. Off.

Johns-Manville TRANSITE PRESSURE PIPE

Classified

WANTED
Operator, Refinery and Chemical Plant

Must have operating experience, be able to prepare operating instructions, prepare schedules for plant start up and plant shut downs and have knowledge of plant processes. Must be able to handle labor problems. Should have equivalent to five or six years' experience in operations. Address replies Box 89, % The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

Western Tennessee drilling block, leases and royalties, geological work now being done prior to prompt drilling. Free complete latest report on oil and gas possibilities for southwestern Tennessee on request. Write for particulars. SOUTHERN MINERALS DEVELOPMENTS, 1212 Three Sisters Building, Memphis, Tennessee, telephone number 5-5468.

FOR SALE
DIESELS and PUMPS

Six new 1947 unused 475 BHP 5 cylinder Baldwin Model VG Diesel Engines, four connected to Ingersoll-Rand Multi-stage Centrifugal Pumps with Farrel-Birmingham Step-up Gears and two connected to Worthington Horizontal Triplex Double Acting Pumps, all units complete with Falk Couplings, Lummus Coolers, other accessories. Location Ohio, immediate delivery. Direct inquiries to The Buckeye Pipe Line Company, Joseph Steele, Purchasing Agent, Room 2200, 300 Broad Street, New York 4, N. Y.

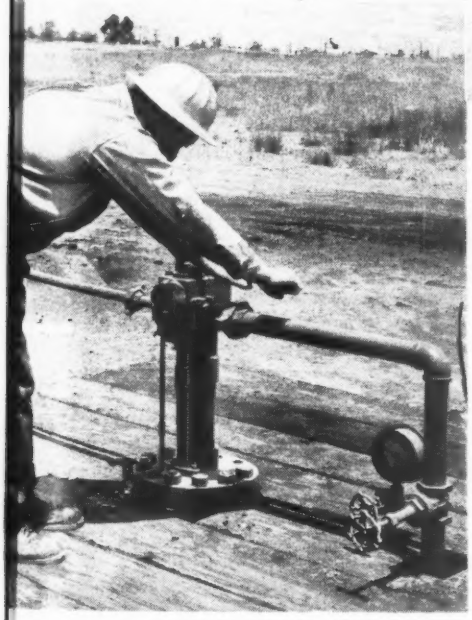
WANTED
PETROLEUM ENGINEER

To supervise the completion of rotary drilled wells. Must be thoroughly experienced in Mid-Continent and Gulf Coastal areas. Liberal salary for capable man. Correspondence confidential. Box 76, % The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

WANTED

Graduate Mechancial Engineer to supervise maintenance of deep well rotary drilling rigs. Must be thoroughly experienced and capable. Good salary. Give past record. Your letters held confidential. Box 87, % The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

Free Pumping



When you combine multiple-well operation with *Free Pumping* you make *two* important savings. You save on equipment and you save on pumping operating costs. For instance, on a 10-well installation, with pump setting depths of 5,000 feet, you can save from $2,000 to $3,000 per well, or a total of $20,000 to $30,000. And that's only the beginning. By eliminating the pulling and running of subsurface pumping equipment, you can cut your pumping operating costs as much as 40%.

Multiple Free Pumping combines the two great developments of hydraulic pumping —multiple-well operation and Free Pumping. It gives you the advantage of having your power plant and pumping controls centrally located. It also provides complete flexibility of pumping operations by having your bottom hole pumps available at the surface by the turn of a valve.

If you are not familiar with Multiple-Well Free Pumping, call your local Kobe representative. He will be glad to give you detailed figures on the saving you can make by converting to this advanced pumping method.

Free Pump
KOBE
ONE OF THE DRESSER INDUSTRIES

KOBE, INC. General Offices: Huntington Park, Calif. Division and District Offices: Avenal, Bakersfield and Ventura, Calif.; Vernal, Utah; Oklahoma City and Tulsa, Okla.; Brownfield, Corpus Christi, Dallas, Houston, Longview, Odessa and Wichita Falls, Texas; Natchez, Miss.; Hobbs, N. M.; Great Bend, Kan.; New York, N. Y.

THESE ARE THE DAYS OF FREE PUMPING

Exploration meeting

A joint regional exploration meeting of the Dallas Geological Society and the Dallas Geophysical Society, local section of the Society of Exploration Geophysicists, will be held November 18-19, at Dallas, Texas.

Morning and afternoon technical sessions will be devoted to papers dealing with problems of exploration for petroleum hydrocarbons. A reception and dinner dance will be held Friday evening, November 19.

The Adolphus Hotel will be headquarters for the meeting. Anyone desiring to attend the meeting from out of town is urged to make reservations promptly with the Adolphus Hotel. In requesting reservations it is asked that it be specified that they are for the purpose of attending the regional meeting.

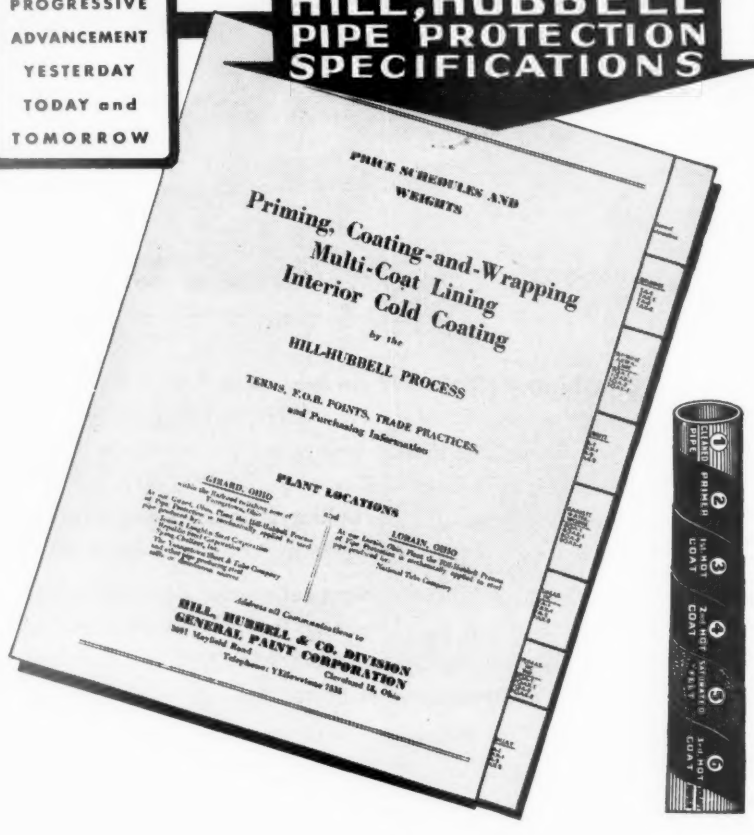
Hughes Tool director

Fred W. Ayers, senior vice president and managing director of Hughes Tool Company, announced the naming of Harry E. Rogers, vice president, as a member of the board of directors of the company. Rogers has been with Hughes since 1945, since which time he has been promoted from manager of production to vice president in charge of manufacturing.

of Special Interest to Pipe Line Engineers

PROGRESSIVE ADVANCEMENT YESTERDAY TODAY and TOMORROW

HILL, HUBBELL PIPE PROTECTION SPECIFICATIONS



The HILL, HUBBEL Price Schedules and Weights Specifications • • • is a handy engineers guide for you to estimate your absolute pipe protection costs, while the job is still in the planning stage. Our production schedules enable you to predetermine delivery dates, so that you have not only the cost, but also the approximate delivery date at job site for your HILL, HUBBEL coated and wrapped pipe.

Hill, Hubbell and Company

Division of GENERAL PAINT CORPORATION

3091 MAYFIELD RD. CLEVELAND, OHIO.

Assistant sales manager

K. F. Forsyth, manager of California and export sales of Emsco Derrick and Equipment Company, announces the appointment of Vaughn A. Euge to the post of assistant manager of California and export sales.

V. A. Euge

K. F. Forsyth

Vaughn has been with Emsco since 1933, starting in the shop and advancing via production control, warehouse, material control, and sales order, to his present position. He attended Loyola University, where he graduated with a bachelor of science degree, majoring in commerce and finance.

Club officers

Alfred A. Northacker, fabricated steel buyer, The M. W. Kellogg Company, New York City, was installed as president of the Metropolitan Purchasers' Assistants Club at the annual meeting held in the Midston House on September 14. Northacker, with the M. W. Kellogg Company since 1936, handles the purchase of all pressure vessels, heat transfer equipment, etc.

A. A. Northacker

Other officers include: Lester N. Read, Purolator Products, Inc., vice president; John J. Sharkey, Culbert Pipe and Fittings Company, secretary, and Robert O. Condit, American Oil and Supply Company, treasurer.

Division manager

Appointment of Dale Ruse as division manager of Texas and New Mexico for the H. C. Smith Oil Tool Company has been announced by Ronald C. Smith, general sales manager. Ruse will make his headquarters at Odessa, Texas. He has been with the company for the last 11 years and was formerly branch manager at Oklahoma City, Oklahoma.

Dale Ruse

Bull's-eye

WITH THE ~~NEW~~ *Proved*

LARKIN CENTRALIZER

THE sole function of a casing centralizer is to center the casing in the hole in which it is set—and to do so without injury to the well bore.

THAT'S WHY—for centering strength, the Larkin Long Type (Bull's-Eye) Centralizer is constructed with two spring sections in tandem. The shorter arc gives greater strength. There are twice the usual number of arcs—offset to give greater peripheral bearing on the wall of the hole and from *four to twenty times the centering strength of other centralizers.*

THAT'S WHY—to prevent injury to the well bore, the Larkin Long Type Centralizer is equipped with straight rather than helical spring staves. This eliminates the scraping action inherent in the construction of centralizers with helical staves.

Larkin Centralizers are available through Supply Stores everywhere.

THAT'S WHY—for rugged durability, the Larkin Long Type Centralizers are constructed with 3/16" x 1½" high quality spring steel staves, riveted, not welded, to sturdy end and center rings.

THAT'S WHY—Larkin's Field Representatives, after coming off a complicated cementing job, can report as follows—*"12 of our long centralizers were run to bottom, pulled and later rerun. When they reached the surface they looked like new—well was 8,547' deep."*

On the same job another man reports—*"They saw the centralizers after the round trip, and were especially complimentary about their condition. The centralizers were not distorted in any way, and turned as freely on the pipe as when they were installed. The paint was rubbed off the staves where they contacted the wall of the hole."*

THAT'S WHY—after field and laboratory tests made on Larkin Long Type (Bull's-Eye) Centralizers by oil company engineers, another representative can report as follows: *"The pipe was run 7,000' under normal conditions. After reaching bottom the casing was rotated for better than two hours. The result was that when the joint was returned to the surface all centralizers were in good shape and the use of centralizers that can be rotated through will be highly recommended."*

"A compression and deformation test was made—ours withstood better than 2,000 pounds more weight than any of the others. This test placed ours above all the others."

THAT'S WHY—it is your advantage to use Larkin Long Type Centralizers to center your pipe. They will increase the efficiency of other tools and methods that might be employed to better your cement job.

Larkin Centralizers are available through Supply Stores everywhere.

LARKIN

...Through Your Supply Store

LARKIN PACKER CO., INC.

ST. LOUIS, MO.

Paddock Sales of Texas

Sales Agent for Paddock Engineering Company of Texas
3727 Atwell St. Dallas 9, Texas • M & M Bldg., Houston 2, Texas

JENSEN'S YOUR UNIT

You've heard of a musician's musician. In this same sense Jensen is the engineer's pumping unit.

Look closely next time you see one. Bearings are extra large. Sampson post and base are strong and rigid. Gears are built to take overload and shock. Actually, Jensen units are built by engineers to meet YOUR exacting requirements for long-lasting low cost operation.

Write for specifications and see. Do it today.

JENSEN
BROTHERS MFG. CO.
Coffeyville, Kansas, U. S. A.
Export Office: 50 CHURCH STREET
NEW YORK CITY

South Central Region NACE meets

The South Central Region of the National Association of Corrosion Engineers met in Tulsa, Oklahoma, September 20 and 21 to hear a program that included many valuable technical papers on the subject of corrosion in the petroleum industry.

On the opening day F. L. LaQue, International Nickel Company, and president of NACE, delivered a paper on "Galvanic Corrosion as Related to Oil and Gas Well Fluids." D. T. MacRoberts, United Cas Pipe Line Company, had as his subject "Control of Corrosion in Condensate Wells." In the afternoon A. F. Blumer, Esso Standard Oil Company, spoke on "Crude Still Overhead System Corrosion:" W. S. Janssen, Pan American Refining Corporation, talked on "Steam Reboiler Corrosion:" T. L. Hart, National Zinc Company, on "Corrosion Problems in the Manufacture of Sulfuric Acid," and H. M. Wilton, The Texas Company, on "The Microscope as an Aid in Solving Corrosion Problems." A movie on melting and refining of modern steels was shown by courtesy of Allegheny Ludlum Steel Corporation.

On the second and last day of the meeting a symposium on internal protection of sour crude storage tanks was held with R. L. Bullock, Interstate Oil Pipe Line Company, as leader. W. R. Smith, Nukem Products Corporation, delivered a paper on "Preliminary Evaluation of Resinous Coatings." M. W. Belson, D. E. Stearns Company, spoke on "Technical Factors in Testing Pipe Line Coatings;" H. A. Robinson, Jr., Dow Chemical Company, talked on "Installation and Performance of Magnesium Ribbon Anodes," and E. R. Doremus, Cathodic Protection Service, on "Engineering Aspects of Cathodic Protection."

In afternoon, S. E. Trouard, New Orleans Public Service Company, Inc., gave a paper on "Electrolysis and Corrosion Experiences on 110-kv Underground Transmission Lines:" A. D. Simpson, Jr., United Gas Corporation, talked on "Mitigation of Corrosion on a City Gas Distribution System," and the paper by J. P. Oliver, National Carbon Company, Inc., was on "The Value of Backfill With Carbon and Graphite Anodes."

Officers of the South Central Region are L. F. Scherer, The Texas Pipe Line Company, director; Donald B. Good, The Texas Pipe Line Company, chairman; Nathan Schofer, Cities Service Refining Corporation, vice chairman; Thos. E. P. Kelly, James E. Mavor, secretary-treasurer, and Tom R. Statham, Magnolia Pipe Line Company, assistant secretary-treasurer.

Local committee for meeting. Front row, left to right: Armon H. Bost, Midwestern Engine and Equipment Company, secretary; J. C. Stirling, Stanolind Pipe Line Company, general chairman; F. E. McNulty, Koppers Company, tickets; and Irene Gadelman, Stanolind, entertainment. Standing: D. B. Good, The Texas Pipe Line Company, regional chairman; T. D. Williamson, Jr., T. D. Williamson, Inc., publicity; H. M. Cooley, Bethlehem Steel Company, registration, and Ken H. Miller, Stanolind, entertainment.

Factory warehouse

Tube Turns, Inc., has established a modern factory warehouse in Tulsa, Oklahoma, at 317 South Detroit Avenue. Robert J. Tyler, Mid-Continent district manager, who formerly had his office at 311 Tuloma Building, is in charge of the new project. William R. Emrich, who was transferred from the Louisville sales department to Tulsa, is chief clerk. W. J. Hamilton is warehouse foreman.

The new warehouse, with its huge stock of Tube Turn welding fittings and flanges, not only will mean faster deliveries and more complete service than has heretofore been available in Tulsa, but there will be another advantage as well. Users, designers, and erectors of industrial piping will be able to consult directly with the research and engineering divisions of Tube Turns.

District manager

Appointment of W. M. Watkins as district manager of Mack Trucks' Indianapolis branch is announced by A. C. Fetzer, vice president. From headquarters at 421 Kentucky Avenue Watkins will direct Mack truck, bus, and fire apparatus sales and service for the Indianapolis territory. Prior to assuming his new duties he was wholesale manager in Dallas.

McCullough

with the

FINEST FISHING TOOLS

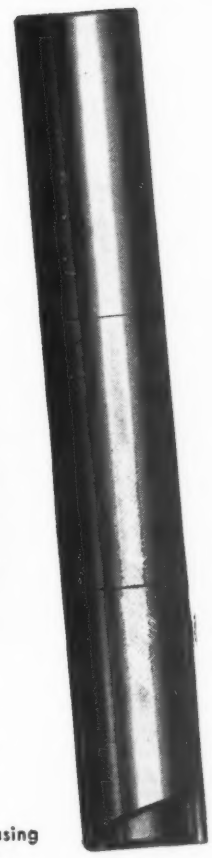
•

POSITIVE KNOWLEDGE
of just where pipe is stuck, and

•

THOROUGHLY EXPERIENCED MEN

Double-Acting
ROTARY JAR
Strikes Blows Both
UP and DOWN



Rotary Releasing
SOCKET

Rotary
Releasing
SPEAR

Self-
Feeding
EXTERNAL
CASING
CUTTER

BUMPER
SUB

The
MAGNA
TECTOR
shows just
where pipe
is stuck

Long Knife
Internal
CASING
CUTTER

McCullough TOOL COMPANY
5820 South Alameda St., Los Angeles 11, California
405 McCarty Avenue, (P. O. Box 2575) Houston, Texas

26 SERVICE LOCATIONS

TEXAS: Houston, Alice, Cisco, Corpus Christi, McAllen, Odessa, San Angelo, Tyler, Victoria, Wichita Falls
OKLAHOMA: Oklahoma City, Guymon
Healdton
MISSISSIPPI: Laurel
NEW MEXICO: Hobbs
KANSAS: Ulysses
CALIFORNIA: Los Angeles, Avenal, Bakersfield, Ventura
MONTANA: Cut Bank
LOUISIANA: Houma, Lake Charles, New Iberia, Shreveport
WYOMING: Casper

EXPORT OFFICE: 30 Rockefeller Plaza, New York 20, N. Y.

General sales manager

John S. Conway

John S. Conway, formerly export sales manager for the Koehring Company of Milwaukee, has been appointed general sales manager. At the same time, Koehring named John E. Chadwick assistant sales manager and R. E. Stewart export sales manager. In his new post, Conway succeeds J. F. Robbins who becomes president and general manager of the Capitol Equipment Company, a Koehring distributor in Harrisburg, Pennsylvania.

Texoma elects

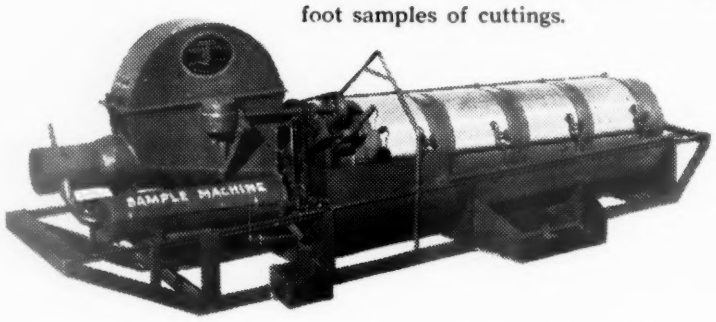
C. J. Hochenauer, president-treasurer of the Texoma Supply Company, announces the election of the following offices:

James M. Cleary, executive vice president; Ray H. Smith, vice president in charge of sales, and Warren A. Read, secretary. These officers, plus Richard Tull, will constitute Texoma's board of directors.

"KILLER" SHALE SAYS:

WHY DIDN'T SOMEONE TELL ME THEY HAD A THOMPSON SHALE SEPARATOR ON THIS WELL?

Shale and abrasives are given the bum's rush when drilling mud goes through a Thompson Shale Separator. Only clean mud, with nothing to chew up expensive drilling equipment, goes back into the well. And there's a Thompson model for any volume of mud flow! The biggest mud pump now in operation can't pump too fast for a Thompson "DWF"—the largest of the Thompson models. *Low cost to buy... no cost to operate!* Attached SAMPLE MACHINE adds to profits by providing accurate foot-by-foot samples of cuttings.



Write Today for Free Illustrated Folder Containing Complete Data on all Thompson Separators!

THOMPSON TOOL CO.

IOWA PARK, TEXAS

KEEPS DRILLING MUD CLEAN — PROVIDES *TRUE SAMPLES* OF CUTTINGS

Advertising manager

H. L. Cunningham

H. L. "Bob" Cunningham, Oklahoma City advertising executive, has recently joined the sales headquarters of the International Derrick and Equipment Company at Dallas as advertising manager. Prior to joining the Ideco group, "Bob" represented an industrial advertising agency in Oklahoma City, handling oil field equipment advertising for manufacturers in Oklahoma, Texas, and New Mexico.

Recent Baker promotions

From: West Texas district manager at Odessa. To: Assistant division sales and service manager, central division, Houston.

R. D. McBrian

C. C. Taylor

From: Branch manager, Odessa. To: West Texas district manager.

R. S. Bedillion

From: Branch manager, Victoria. To: Branch manager, Odessa.

C. A. Greve

From: Staff assistant, Houston. To: Branch manager, Victoria.

R. L. Ramby

From: Sales and service engineer, Corpus Christi. To: Branch manager, same city.

Manager pipe department

H. B. Catlow, president of Republic Supply Company, announces the appointment of E. H. (Gene) Trammell as manager of Republic's pipe department with headquarters in Houston. Trammell comes to Republic with a rich background of experience and wide acquaintance throughout the petroleum industry in both domestic and foreign fields. He served for more than 10 years in the materials division of the Standard Oil Company of New Jersey in South America and during the last 10 years has been engaged as export representative in New York for several leading oil equipment manufacturers.

E. H. Trammell

Announces appointments

Sidney Shuman, general sales manager of Fluid Packed Pump Company, announces the following personnel changes:

Glen Peters has been made assistant sales manager for the Mid-Continent, Gulf Coast, Rocky Mountain, and Eastern area with headquarters at Oklahoma City. Peters is a veteran oil man who has served Fluid Packed Pump Company since 1941.

Glen Peters

Jack Hampton

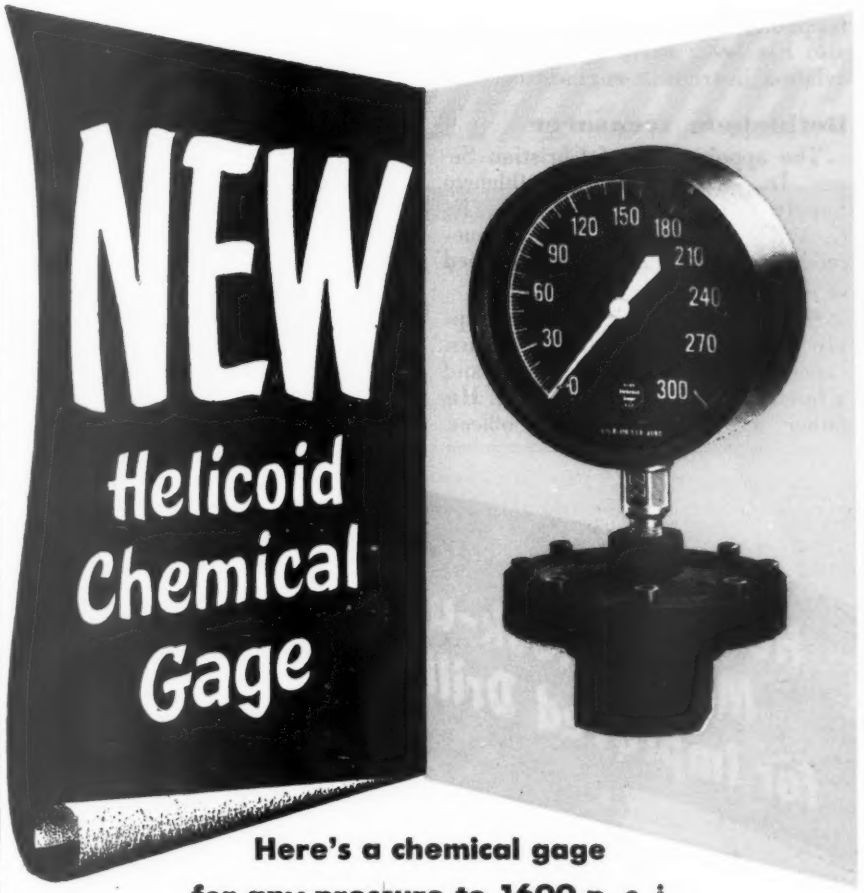
Jack Hampton, formerly a California salesman for Fluid Packed Pump Company, has re-entered the company's employ and been made factory representative for Mississippi with headquarters at Laurel.

Charles Cameron, well known pump salesman in California, Montana, and Oklahoma, has been appointed Arkansas factory representative with headquarters at El Dorado.

Sales representative

Justin J. Callahan has joined Federal Telephone and Radio Corporation, Clifton, New Jersey, associate of International Telephone and Telegraph Corporation, as sales representative covering the New England territory for Federal's mobile radio division.

Callahan, a native of Brooklyn, N. Y., has been associated with radio-

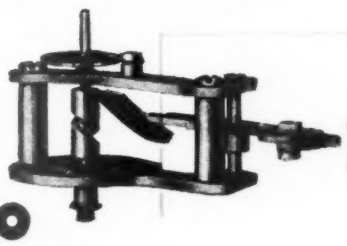


Here's a chemical gage for any pressure to 1600 p. s. i. and also for vacuum or compound ranges, and temperatures to 300° F.

An accurate pressure gage for use where chemicals or viscous liquids either corrode or clog a Bourdon tube.

The diaphragm is "TEFLON" which resists practically all corrosive chemicals. The diaphragm chamber is supplied of any metal most suitable for the service.

Write for complete information about the new Helicoid Chemical Gage.



Only Helicoid Pressure Gages have the Helicoid Movement

ACCO

TRADE MARK

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE
Bridgeport 2, Connecticut

telephone sales for some years and also has been active in marine and aviation instrument engineering.

Bethlehem treasurer

The appointment of Christian Seger, Jr., as treasurer of Bethlehem Supply Company is announced by G. A. Tompson, president. Seger succeeds A. W. Tarkington who resigned to join Continental Oil Company.

Seger comes to the Bethlehem Supply Company with nearly 20 years' experience in credits and finance and a family background in banking. His father, a former Tulsa bank officer, and present independent oil operator, moved his family from Illinois in 1916.

After graduating from Central High School in Tulsa, Seger attended the University of Illinois from which he was graduated in 1930.

Immediately thereafter he was employed by National Bank of Tulsa as a clerk in the credit department, from which position he was advanced to the rank of assistant cashier and placed in charge of the department. Later he served as head of the personal loan department.

He left the bank in 1938 to take the position of credit manager of Bethlehem Supply. He served the company in this capacity for three years and then was promoted to resident manager at Houston, Texas.

With the outbreak of war, Seger was commissioned in the U. S. Navy and two years of his service were spent with the Naval Forces in the South Pacific Theater. He was released to inactive duty in October, 1945, with the rank of lieutenant commander.

Upon his discharge from the service, he was elected vice president of National Bank of Tulsa and served as an officer in the commercial loan department.

Texoma secretary

Warren A. Read, formerly with Ernst and Ernst, Denver, Colorado, national firm of accountants, has been elected secretary of Texoma Supply Company, according to announcement made by Carl J. Hochenauer, president. Read, formerly with Price, Waterhouse and Company of Chicago, is a graduate of the University of Illinois. He served three years in the air corps of the United States Army during the recent war.

W. A. Reed

H. C. Wiess dies

Harry C. Wiess, chairman of the board of the Humble Oil and Refining Company, died at his home in Houston, Texas, August 26. He was one of the founders of the company and had participated in its guidance to a position as one of the nation's largest producers of crude oil.

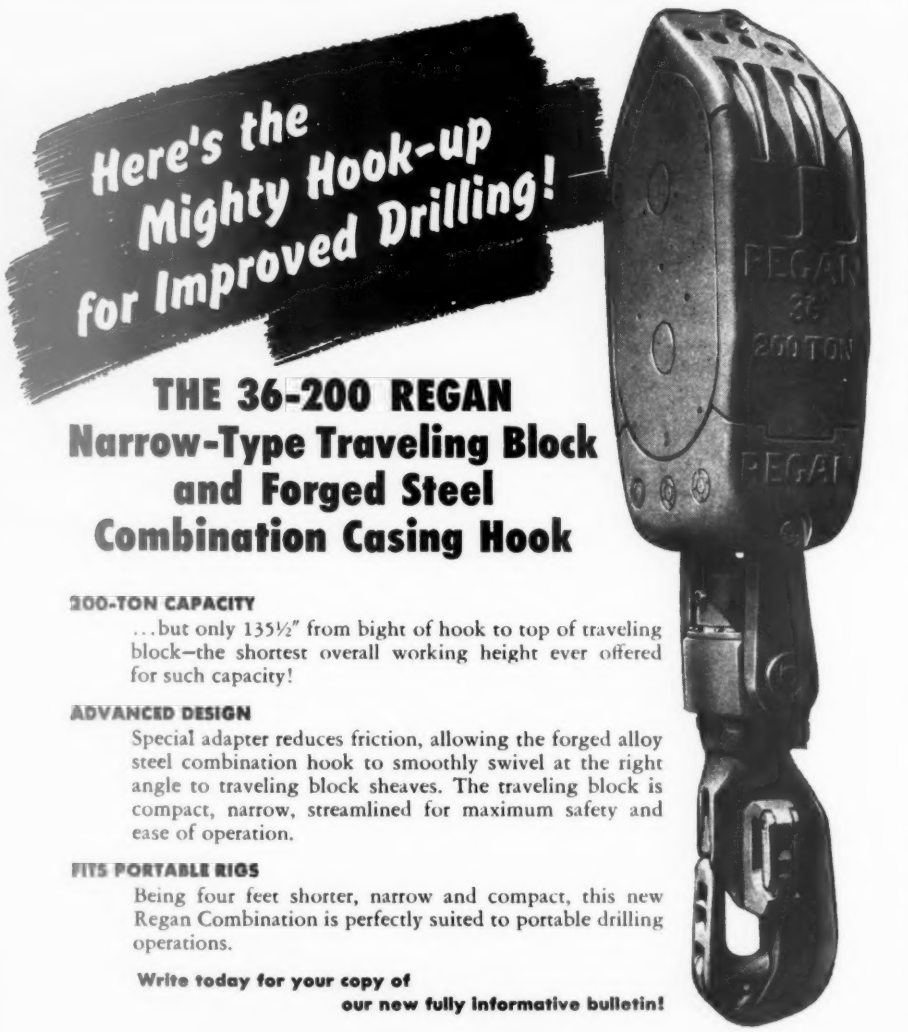
H. C. Wiess

When Humble was incorporated in 1917, Wiess put into it some of the producing properties of his Paraffine and Reliance Oil Companies and became a director and vice president of the new concern.

From 1919 to 1933 he was responsible for the company's refining activities and directed construction of the Baytown refinery.

He became executive vice president in 1933 and was named president four years later, serving in that capacity 11 years until he became chairman of the board, May 10.

Wiess also was a director of the American Petroleum Institute, a member of the National Petroleum Coun-



THE 36-200 REGAN
Narrow-Type Traveling Block and Forged Steel Combination Casing Hook

200-TON CAPACITY

...but only 135½" from bight of hook to top of traveling block—the shortest overall working height ever offered for such capacity!

ADVANCED DESIGN

Special adapter reduces friction, allowing the forged alloy steel combination hook to smoothly swivel at the right angle to traveling block sheaves. The traveling block is compact, narrow, streamlined for maximum safety and ease of operation.

FITS PORTABLE RIGS

Being four feet shorter, narrow and compact, this new Regan Combination is perfectly suited to portable drilling operations.

Write today for your copy of our new fully informative bulletin!

Regan Quality

Forge & Engineering Co.

SAN PEDRO, CALIF. HOUSTON, TEXAS

Exclusive Mid-Continent Representatives:
Hunt Tool Co.,
P.O. Box 1436, Houston, Texas

Exclusive Export Representatives:
Hunt Export Co., 19 Rector St., New York, N. Y.
Avda Pte., R. Saenz, Pena 832, Buenos Aires, Argentina

Here Goes Another UNIT RIG!

The three engine draw works unit shown above weighs approximately 55,000 lbs. The draw works and the transmission are in the same housing, which is welded to the main base on which the engines and the compound system are mounted. With this arrangement, the entire assembly, in most cases including prime movers, can be transported in a single truck load—ready to operate when set on location.

The UNIT RIG U-15 is designed for drilling up to 7,500 feet, and for work-over jobs on the deepest wells. Write for literature.

UNIT RIG & EQUIPMENT CO.
TULSA, OKLAHOMA U.S.A.

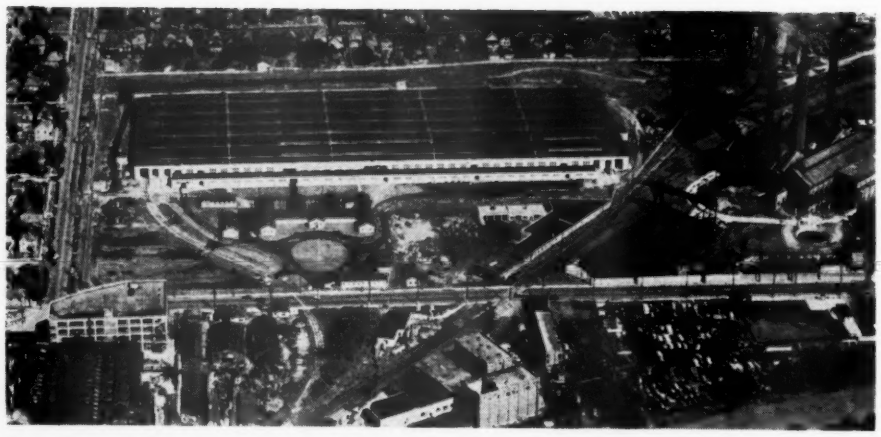
DESIGNED FOR THE JOB....

Exclusive Export Representative: MID-CONTINENT SUPPLY CO., 42 Broadway, New York City. Cable Address: MIDUNITRIG.

cil, a charter trustee and permanent member of the board of Princeton University, and a member of the board of trustees of Rice Institute, Houston.

Moves to new plant

The consolidation of the movement of both personnel and equipment into its new 19-acre plant site at Indianapolis, Indiana, has been completed by Peerless Pump Division of the Food Machinery Corporation, and tempo of final construction is being stepped up to make this plant one of the country's finest examples of modern pump manufacturing and production facilities, according to F. E. Fairman, Jr., vice president of the Food Machinery Corporation and general manager of its Peerless Pump Division.



Peerless' new Indianapolis plant is the former Fall Creek Ordnance works and was acquired from the War Assets Administration late in 1946.

Situated approximately two miles from the heart of downtown Indianapolis at 2005 Northwestern Avenue, the new plant forms an impressionable picture of steel and concrete as its main factory building alone, which is 300 ft wide by 870 ft long, and contains 261,000 sq ft of floor space. Paralleling and to the west of the main factory structure is a 30-ft by 800-ft structure comprising locker and shower accommodations for over 1200 employes. Remodeling of this section has been made to include a dispensary, receiving and shipping department offices. This building is in turn flanked by a 4500 sq ft area housing the production management and control sections. Peerless Pump Division's main office building at Indianapolis now comprises some 11,000 sq ft, with an adjacent building of similar design, of 1700 sq ft, remodeled for use as a sales training building.

Works manager of the Peerless Indianapolis plant is H. J. McKenzie; assistant works manager is C. N. Adams. The plant is producing units of the complete line of Peerless pumps, vertical, horizontal centrifugal, and domestic water systems. Other departments now located at the plant include the centrifugal sales section and the small products sales section, plus a designing and engineering staff, and accounting and credit personnel.

Department manager

T. J. Hodan, water conditioning department sales representative in the Milwaukee district office of Allis-Chalmers since July, 1942, has been named manager of the company's water conditioning department. Hodan succeeds W. L. Manly, who has been appointed manager of Allis-Chalmers dealer sales.

ARCCO
ARCCO ANUBIS
LIQUID GRAVITOMETER
...for PIPELINES, REFINERIES, GASOLINE PLANTS
This ruggedly built instrument of laboratory accuracy is ideal for quick checking and for continuous recording of Specific Gravity of liquids under line pressure. Changes in Specific Gravity of sample are recorded with a very minimum of time lag. Foreign liquids and gases are automatically purged from sample. No moving joints or stuffing boxes to cause friction or leakage. Temperature corrected, this precision instrument is adaptable to high pressures. Hundreds are in daily use in plants and refineries of major companies. Also available as a controlling instrument. Send for bulletin No. 111A.
AMERICAN
RECORDING CHART CO.
3113 E. 11th St. • Los Angeles 23, Calif.
Available for Early Delivery
SEND FOR BULLETIN No. 111-A

Petrolic Personalities

By DICK SNEDDON

Out at Sugar Valley in Matagorda County, a short time ago, Humble Oil and Refining Company's public relations director, Bill Finnegan, put a new automatic rig through its amazing paces, for the edification of a select coterie of press men and others of the intelligentsia. Knowing that the average press rep doesn't retain information too well on an empty stomach, Bill also saw to it that the inner press men were adequately regaled. According to the Eye, the new rig is about as modern as they come. It is in reality a field laboratory for drilling research, and automatically speaking has more sense than a lot of humans. It pulls pipe, breaks out the stands, and stacks them up in the corner as neat as you please, without a bit of effort from the crew—much to the joy of the crew. Even the derrick man gets a virtual vacation! All he needs to do is press a lever and a mechanical hand reaches out, grabs the pipe and pulls it back to the finger board. Pumps are started and stopped by flicking air switches on the derrick floor, and drilling mud is kept in the proper state of admixture by means of a push-button egg beater in the suction pit. When actually drilling, the drill stem is lowered by a mechanical integrator that controls the weight on the bit and other pertinent factors. As nearly as we can figure it, the only drawback to the whole deal is that the progeny of this drilling crew, a few hundred generations up the line, are going to be born with much overdeveloped forefingers from pushing too many buttons.

Another son of Glockamorra, Jack Shannon, took an expert hand in the arrangements for the Sugar Valley expedition, and acquitted himself with more honors than Ely Culbertson. Jack introduced everybody to everybody else with a finesse that would have pleased Emily Post no end, and he also kept events rolling along right on schedule, so that the press boys had no time to brood. Assistant petroleum engineer, Doug Ragland, is similarly worthy of mention for his fine description of the rig and all its appurtenances. He particularly emphasized the fact that every aspect of the new development involved something in the way of improved conditions and added convenience for the drilling crews. It looks as though the driller of the future will just rise on one elbow each morning, press the right button, and then go right back to sleep again. Also, the entire mechanism is so super-safe that we are seriously thinking of selling our Bandaid stock.

Some months ago we made it known through this compendium of small talk that one DeVere Vaught Carter, chief petroleum engineer for Magnolia, had planted sizable acreage to acorns on his White Rock Lake estate. Late reports on the project indicate that Squire Carter has had to cultivate something awful to provide the necessary air and nourishment for the sturdy young oaks that are now peering up through the earth into their wonderful new world. This unique bit of forestation was for a time threatened by a lush sprouting of Johnson grass, so the Squire simply bought him a tractor and pushed the Johnson grass right back where it came from. An interesting sidelight to the story is that the tractor aforesaid is of the seatless variety, and its proprietor has found stimulating mental exercise in anticipating its meanderings, and meeting it at some convenient spot on its return journey. However, he is planning to use the income from his first acorn crop to purchase a saddle, so that there-

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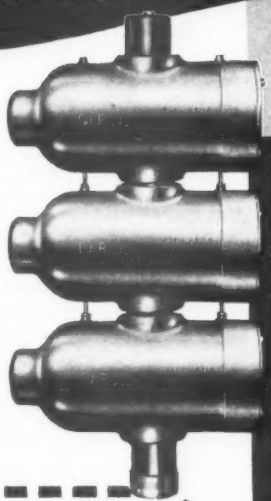

Baroid Pulsation Dampeners absorb the shock and surge of all types of reciprocating pump installations, and more than save their cost by reducing damage to equipment and providing smoother, quieter operation. Some evidence even points strongly to the possibility that pulsation transmitted to the formation increases the chances of caving and lost circulation.

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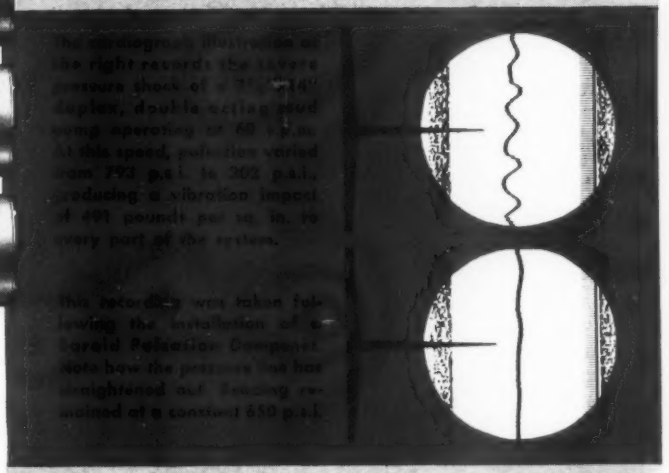

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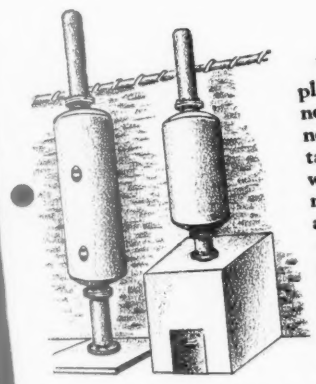

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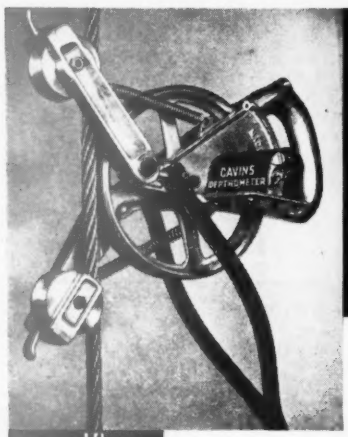

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THE CAVINS DEPTHOMETER

after he will be able to accompany the robot plowman on its agrarian adventures.

And while the discussion is on educational matters, we have just learned that Dick Guiberson has been vacationing up in Santa Fe, New Mexico, where he was met by brother Nat and his wife, and the party engaged in a short but intensive study of the Pueblo Indians. Dick tells us that the Hopi snake dance is very similar to the performance of a golfer in a sand trap, and may actually be of Scotch origin. since a couple named McHopi are known to have come to America as stowaways on the Mayflower in 1620. Isn't history the darndest stuff? It has nothing to do with the Indians but Walt Greenfield, Frank Morgan and Dick were recently appointed grand whooper uppers for the Petroleum Production Pioneers, and will be responsible, heaven forgive them. for coordinating and correlating the sporadic outbursts that are loosed by the members in the fictitious name of harmony. Another substantial trio, consisting of Si Rubel, Tom Pike. and Paul Huggins, are delegated to segregate PPP's instrumentalists and determine whether or not the miscellany of bleats and oompahs they call music has any commercial value. These experiments are being awaited in a welter of fear by the non-playing members who someday are going to have to listen to the cacaphony.

Pat Darney, Stanolind's drilling and production safety supervisor in the Fort Worth division (including North and West Texas and New Mexico), gave the boys at the Fort Worth Engineering Club a free movie show in color recently that presented the subject of safety in a mighty effective way. Pat is a strenuous propounder of safe operation in all its phases, and he presented very forcibly his contention that safety is largely a matter of practice in forming the right habits; that it is a tangible and substantial saver of money. and that it eliminates the maximum of pain and suffering for the workers. We hate to inject a facetious note into a serious discussion, but in our younger days we were employed by the Canadian Pacific Railway in Winnipeg as a railway car cleaner and in this tremendous responsibility were associated with a very safety-conscious Irishman, who used to tell his helper on the roof of the car, "Don't come down the ladder till I get back, Mike—I've taken it away." Then, of course, you have heard Denny Driscoll's story of the careless rousty who took off his safety helmet, and as you might expect, just at that moment a rigger dropped a hammer from high in the derrick. It struck the rousty right on top of the head and gave him a terrific case of fallen arches.

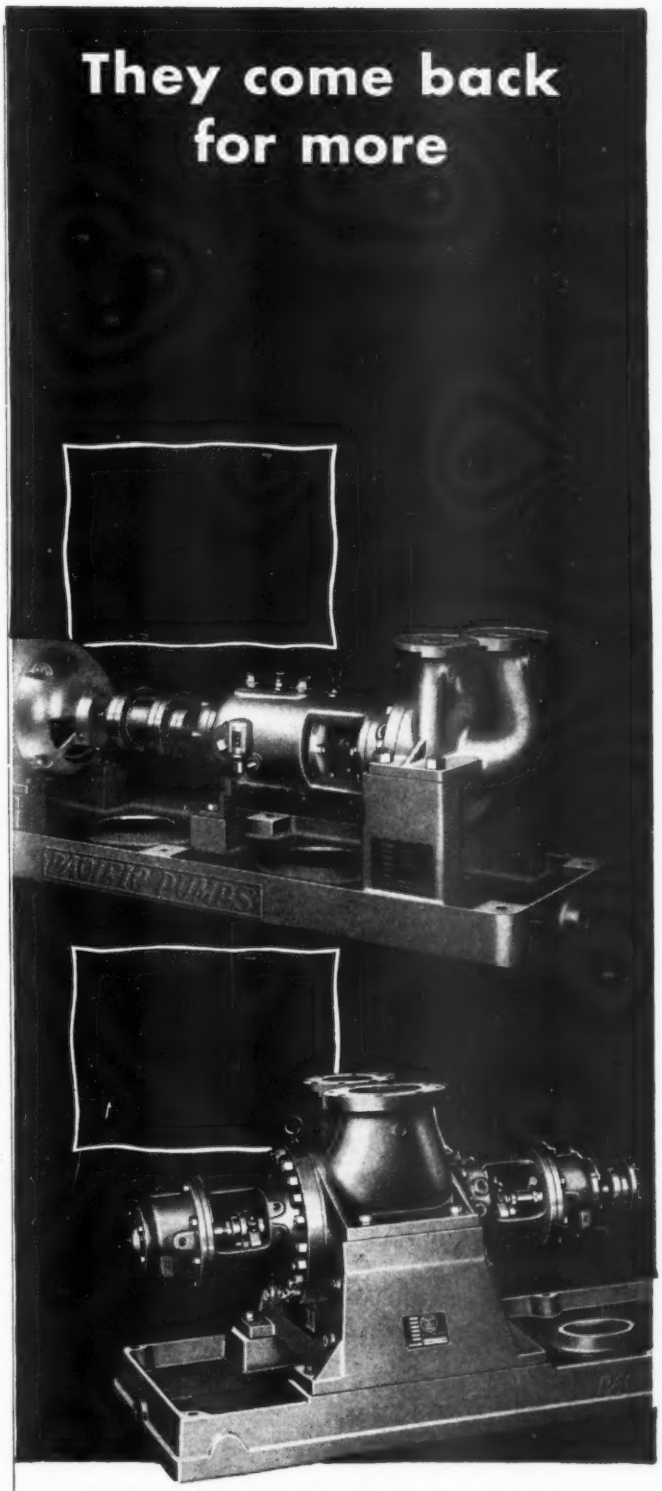
Ray Stehr, chief geologist for Seaboard Oil Company at Dallas, and prexy of the local geological society, has been running around like a tightly wound rotifer appointing endless committees and lining up all the details of a pretentious program for a grand convocation of the Geological and Geophysical Societies at the Baker Hotel, Dallas, on November 18 and 19, 1948. We understand that Ray simply can't relax while something like this is Stehring him in the face. so until the last piece is fitted into the jig saw puzzle he works without surcease. However, the minute he is satisfied that the situation is well in hand, he intends to hie him to the wilds of Southwest Texas, and there "when the stag at eve has drunk its fill," Ray, infinitely experienced in such doings, will take aim with his trustry rifle so as to hit him if he is really a deer, and miss him if he is a cow. That is the sort of woodcraft that has enabled this nimrod to bag the limit year after year through endless time. Sun believable!

Dashing back to California for a spell, we had a right pleasant visit the tuther day with Hut Erwin, general manager of McCullough Tool Company's western division, and were rejoiced exceedingly to find that he is a native of Santa Paula, where many other great oil men of the west received their petrolic initiation. Hut has had a wealth of experience in the oil fields. He even used to work summers on the St. Helen's lease out Brea way, where we have caught many a

fat black bass with practically no equipment but a frying pan. His dad worked for the old C. V. Hall Company, later absorbed by the Tide Water Associated, so Erwin junior was inoculated with the paraffine virus at a tender age. When he was about 12 years old, he and several other buddies, including such now well known oil men as Cliff Ford, Cecil Sweet, and Willard Moss, built a juvenile cable tool rig out of a defunct washing machine and sundry other home pilfered equipment. They spudded in a well on the old Olinda Land lease and got down to 100 feet. There, stalled by a stuck drill pipe, and pestered by the insistent calls of their respective parents, the kids were obliged to abandon the project. When we arrived at the McCullough hostelry we found Hut dispatching a beautiful piece of plastic sculpture of his own making to Dick Green up at Escalante. It consisted of a prune couchant in a solid plastic globe, mounted on a ritzy black base, and was specifically designed to glorify the prune picker. Apparently Dick designates all Californians as prune pickers, and thinks all prune pickers are—which is ridiculous on the face of it. Sticking strictly to the same neighborhood, we note that Crooks Stafford has joined McCullough's sales staff in Los Angeles. Crooks is a famous individual on several counts. He began his career in Coalinga, worked for Shell for 27 years, and is the originator of the Jo Stafford Fan Club—he must be, he's Jo's pappy.

It's a bit disturbing to learn that our good friend, John Flanagan, leaves M. O. Johnston on September 1, and by the time this appears in print will be associated with his old buddy, Bill Morrison, back in Tulsa, Oklahoma, where Bill has his own pipe line construction organization. John and Bill were kids together up in Casper, Wyoming, and have never quite lost track of each other. We hear tell that Bill did a sweet job for the army engineers in the Pacific during the war, where he was in charge of the pipe line brigade. He started the pipe line concern after he came out of the army and has been going along in good shape since. John was born in Oil City, Louisiana, in a Texas Company field camp, so he certainly comes by his oil interest honestly. He was with KNDA up at Kettleman Hills for six years before he tied up with M. O. Johnston in 1942, and has in recent years spent considerable time in foreign fields. John is a fine looking, thoroughly likable lad, who has made a swarm of friends out thisaway. He is a good fly fisherman, and in off season flails the sod with a viciousness rarely surpassed. It is said that some of his near misses with a three would have almost torn the Mount Wilson seismograph from its moorings.

An interesting and interested visitor in California at the present time is Tony Gheno, driller for Richmond Exploration Company in Maracaibo, Venezuela. Tony has been here for some surgical work but now appears to be completely back to normal. A native of Venice, Italy, he came out to Oregon in 1908 and has since had a wonderfully diversified experience. He has worked in the oil fields of Venezuela, Ecuador, Colombia, Alaska, Bahrein, Egypt, and nearly every producing state of the U. S. Tony is anxious to get back for some good fishing on Lake Maracaibo, and to do some hunting. He tells us that they get lots of wild turkey, doves, and quail down there, and the jungles are so populous with lions and tigers, that the average hunter won't even bother to shoot them unless they have nice expressions for front room throw rugs. Another foreign visitor much in evidence is George "Tommy" Thomas, drilling engineer for Creole at Quiriquire in Venezuela. Tommy was born in El Paso, Texas, is a graduate petroleum engineer from the Missouri School of Mines at Rolla, and went down to Venezuela after a spell with Army Engineers in the Southern Pacific. He is married and has a 2-months old daughter, Georganne. His other hobbies, besides Georganne, are golf and tennis, but he is very modest about his performance.



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Don't, however, let that lure any 100 shooter into a bet. We have invariably found that these modest chaps have a way of raking in the kale. Incidentally, Tommy says he traveled up from Venezuela with Tom Donlan, Richmond's production chief in Maracaibo, and found him tops as a traveling companion.

Comes last minute word of big doings at the Jackson Country Club on August 10, when 250 members and friends of members of the Michigan Oil and Gas Association took a day off to lash the greensward, and otherwise disport in the ways that men love. Among those present from Chicago was Jene Harper, president of Franklin Supply Company, and world famed navigator. Jene recently sailed bravely away from Gary, Indiana, on an ore boat, the James A. Farrell, and never turned back until some 800 miles away he discovered a strange settlement, very good to look upon and inhabited by right friendly people. He has given this place the colorful name of Duluth, Minnesota, which strangely enough is what the natives call it themselves, so there should be no conflict about that. Returning to the Jackson frivolities, it might be mentioned that Harry Weber, the Walworth sharpshooter, another Chicagoan, carded a pair of naturals (77) for 18 holes, and walked off with the low gross money. J. Perry Morgan was given a special citation for throwing a flock of fives—we're still talking about golf. Benny Benezette, Mel Anderson, and Bob Denny came up with a profusion of sixes. Hugh Crider had fewer putts than a stalled outboard. Hugh Goff—why shouldn't he be able to play goff?—almost made a hole in one on the 8th. Ben Timmer whacked out a drive so long they had to trim it down to 255 yards in order to get it in the paper. Others collected for varied accomplishments and misdemeanors—the latter were mostly given horrible mention. Anyway, it was a swell party on the success of which Prexy George Talbot, executive secretary Bill Palmer, and their aids, especially A. H. Ledbetter, are being widely and deservedly congratulated.

Your community will look to *you* on October 14th*

*Oil Progress Day

START PLANNING NOW!

Hood new Ansul president

F. J. Hood

F. J. "Jim" Hood has been elected president of Ansul Chemical Company, Marinette, Wisconsin. He succeeds Harvey V. Higley, who has been named chairman of the board of directors. Hood joined Ansul's California office in 1928. He worked in sales for eight years, returning to Marinette in 1936. In 1939 he was elected secretary and treasurer and was promoted to vice president in 1945.

Other officers elected by Ansul are R. C. Hood, vice president; H. C. Higley, secretary; J. F. Asell, treasurer, and S. R. Holmquist, comptroller and assistant treasurer.

District manager in Venezuela

Clark Bros. Co., Inc., Olean, New York, manufacturers of compressors, announces the appointment of Thomas C. Webb as district manager for Venezuela. His official address is Clark Bros. Co., Inc., Office 119, Edificio Planchart, Puente Mohedano, Caracas, Venezuela.

Webb has had an unusually wide experience in the petroleum industry, covering production, refining, gasoline, and distillate recovery.

After majoring in refinery engineering at the University of Tulsa, Tom worked for some years in the Oklahoma oil fields and with L. S. Gregory, a consulting engineer in Tulsa. He joined the Clark engineering staff direct from the U. S. Bureau of Mines and for the last 11 years has been associated with Clark Bros. in that company's technical service, engineering and sales departments.

Manager sales

Ray R. West has been named manager of sales of Minneapolis-Honeywell Regulator Company products for industrial applications.

West's appointment, said Brown Instrument Company officials, is in line with current Honeywell sales expansion and new products developments for control of temperature, humidity, and pressure in industrial and specialized fields. West, who has filled executive sales positions with Brown Instrument during his more than 20 years with the industrial division of Honeywell, will make his headquarters at the Brown plant in Philadelphia.

Talks on Pelton jack

The Shell Oil Company's Southern Division in California heard a three-hour lecture on the Pelton hydraulic pumping jack recently at the Shell headquarters in Long Beach, California. D. K. Stewart, Shell district production foreman, and the Shell engineers arranged for the lecture in cooperation with Pelton. The talk was attended by approximately 40 production foremen, engineers, maintenance and operating personnel of the Shell organization.

C. J. Woodard, manager sales-service of the Pelton Hydraulic Pumping Jack Department, spoke the first two hours on the operation and maintenance of the Pelton jack. The talk was illustrated throughout with drawings, photographs, and slides. The last hour was taken up at a well site where Shell has a Pelton long stroke jack in operation. Clyde H. Lietzow, Pelton's sales-service engineer in Long Beach, instructed the Shell personnel in the operation of the Pelton jack.

Woodard states that a series of such lectures are planned for the California oil fields in order to acquaint more of the oil companies operating personnel with the Pelton jack.

Howard Butt passes

Howard Butt

Howard Butt, vice president and manager of the New York office of The Wm. Powell Company, died at his home, Side Hill, Morristown, New Jersey, on August 23, in his 58th year. After attending Alabama Polytechnic Institute, where he was a member of Phi Delta Theta, Butt was associated, in sales, engineering and managerial capacities with several large engineering organizations. In 1930 he joined The Wm. Powell Company, valve manufacturers of Cincinnati, Ohio, and was made a vice president in 1944. He was widely known in engineering circles and the valve industry, holding memberships in DTAC, Engineers Club of New York, Economic Club, ASME, Spring Brook Country Club (Morristown), and Sky Top Lodge (Pennsylvania).

Merchandising department formed

Formation of a new department of the Minneapolis-Honeywell Regulator Company to supervise and coordinate the advertising, merchandising, and sales promotion activities of the company has been announced by C. B. Sweatt, executive vice president.

John R. Bergan has been appointed head of the new department as merchandising manager. Other changes include the promotion of Chandler Murphy as advertising manager and John A. Young as sales promotion manager. Murphy succeeds William B. Walrath who has resigned to join the Chicago advertising staff of *Fortune* magazine.

Refinery Supply opens new warehouse

W. A. Schlueter, president of The Refinery Supply Company, Tulsa, Oklahoma, has announced the completion of a new warehouse, adding more than 5000 sq ft of floor space to storage. This new building is now completely stocked with Refinery Supply Company finished material and distributed items. The additional investment is well over $100,000.

Future plans contemplate extending the main building down Fourth Street, east to the corner. It would be used exclusively for the manufacture of the new R. S. Liquid

Recording Gravitometer. Also, it is planned to use the small building, in the center of the picture, as a company cafeteria.

The Refinery Supply Company has been designing and manufacturing laboratory and gas testing equipment for the oil industry since 1918. The first control application ever designed for vapor outlet control towers was covered by applications of W. A. Schlueter, made on March 6, 1918.

The company also serves as a jobber for a number of nationally identified lines of scientific instruments.

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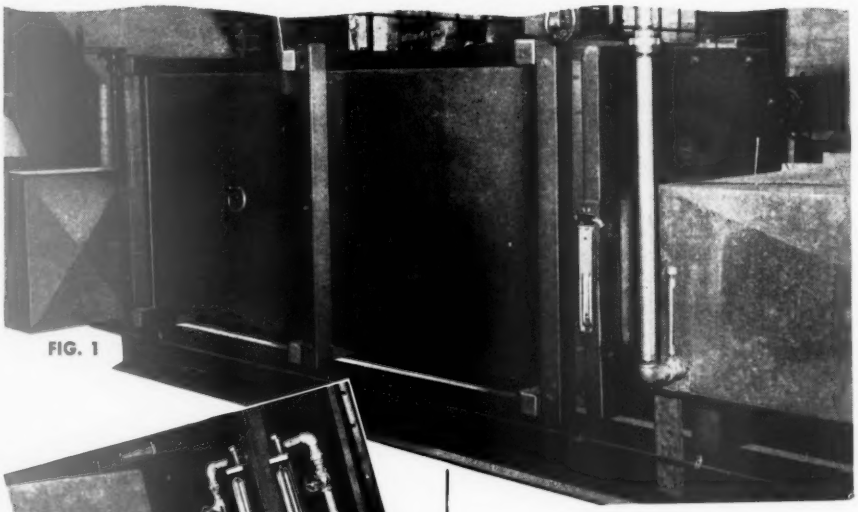

FIG. 1

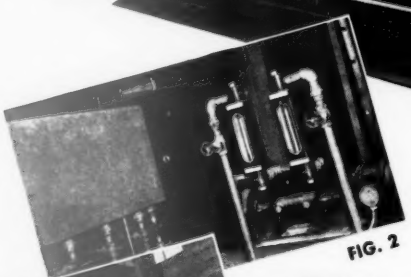

FIG. 2

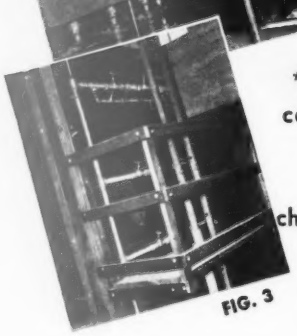

FIG. 3

* FIG. 1 Pre-conditioning chamber holds air characteristics constant during tests minimizing variables.

FIG. 2 Water metering station on full sized test tower.

FIG. 3 Headers provided at different levels to extend scope of test data.

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Eastman transfers

Recent transfers of executive personnel have been announced by H. John Eastman, president of the Eastman Oil Well Survey Company.

C. I. Stokenbury

Clyde I. Stokenbury, manager of the Dallas office for 2½ years, has been made district manager of the Bakersfield, California, office. The Dallas office has been combined with the company's expanded Oklahoma City district.

Roland Armell, former manager of the Bakersfield district, has been made assistant to Ross E. Wiley, Pacific Coast division manager at Long Beach.

Roland Armell

W. D. Compton

Wm. D. Compton, formerly of Eastman's Long Beach division, has been promoted to general field manager of the Eastman organization and transferred to the general offices in Denver.

Don E. Woodward, of Eastman's Houston office, will be placed in charge of a new Eastman office to be opened soon in Abilene, Texas.

G-E professors' conference

Representatives from some 30 colleges and universities throughout the country convened in Schenectady August 25 and then moved to Pittsfield August 26 and 27 for the General Electric Company's second annual conference for professors of chemistry and chemical engineering. Purpose of the conference was to give scientists of the company and the nation's educators an opportunity to exchange scientific experiences and ideas.

Through talks by G-E officials and scientists and tours of the company's installations at Pittsfield, Massachusetts, Schenectady and Waterford, New York, the visiting professors studied General Electric activities in the field of chemistry. They saw research in progress on such materials as paper, insulating liquids, silicone rubber, glass, silicon steel, and syn-

thetic resins, the basis of many modern plastics.

Guest speaker of the conference was Prof. Eric K. Rideal, noted British scientist and Fullerian professor of chemistry in the Royal Insitute in London. In the Schenectady portion of the conference the educators heard Dr. Zay Jeffries, vice president of the General Electric Company in charge of the chemical department speak on "Chemical Activities of the General Electric Company," and Dr. C. Guy Suits, vice president of the General Electric Company and director of research, discuss "Current Activities of the General Electric Research Laboratory." Dr. Charles E. Reed, manager, chemical engineering division, chemical department, spoke of "The Commercial Production of Silicones."

In Pittsfield, Dr. Irving Langmuir discussed "Weather Research;" Dr. Frank M. Clark, consultant, electrical insulation, talked on "Chemical Developments in the Electrical Industry," and Dr. James J. Pyle, director of the plastics laboratory, chemical department, spoke of "The Industrial Development and Production of High Polymers." Maynard M. Boring, manager of the technical personnel division, spoke of "General Electric Cooperation with Educational Institutions," and Karl B. McEachron, Jr., manager of educational activities, chemical department, reported on "General Electric Training Programs."

Others who took part in the program were William W. Trench, secretary of the General Electric Company and chairman of its education committee; Augustus McK. Gifford, engineer, Pittsfield works laboratory; Frank W. Warner, engineering policy manager, chemical department; Robert Paxton, manager transformer and allied products division; Ernest E. Johnson, manager of engineering, apparatus department, and Dr. William E. Cass, chemical division, research laboratory.

Consolidate operations

The Ohio Oil Company announces that production operations in four of its eastern divisions will be consolidated under a new division office to be located at Terre Haute, Indiana.

The Terre Haute division area will include the states of Michigan, Illinois, Indiana, Ohio, Kentucky, Tennessee, Pennsylvania, Virginia, and West Virginia. This region is presently divided into four production divisions with headquarters at Grand Rapids, Michigan, Marshall, Illinois, Findlay, Ohio, and Owensboro, Kentucky.

Purpose of the consolidation is to effect closer coordination of the company's production activities in this nine-state area. Pipe line, refining,

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Here are a few of the reasons why you can count on faster round trips and lower drilling costs when "Le Roi's" power your rig:

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● **Fast acceleration.** Just touch the controls of a Le Roi drilling engine and watch it jump. This immediate response, even under heavy loads, reduces round-trip time. Le Roi owes this fast acceleration to its unique valve-in-head design, short stroke, and new carburetion.

● **Dependability.** Here's why Le Roi users have less down-time, less trouble: Block construction provides rigidity. Valve-in-head design is easily accessible, speeding maintenance. Parts are 100% interchangeable. Complete part stocks and prompt service are available in every producing area.

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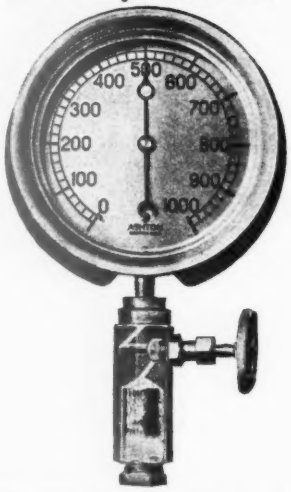

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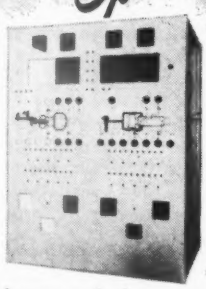

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and marketing organizations of the company are not affected by the change.

To manage the newly constituted division, the company has appointed A. L. Henderson, former division production superintendent at Houston, Texas. Associated with Henderson in Terre Haute will be I. G. Burrell, division production superintendent; W. E. Schoeneck, division petroleum engineer; R. E. Knipe, division geologist; E. J. Giffel, division land man; N. L. Battenschlag, division comptroller; J. F. Diver, division attorney, and E. B. Peters, supervisor of personnel.

The total staff that ultimately will be moved to Terre Haute will number approximately 70 employes.

J. D. Wheeler, who has been division manager in Michigan for the last two years, has been reassigned to the newly created position of district manager of operations in West Texas and New Mexico in the Houston division. Wheeler will have his headquarters in Midland, Texas.

The company will maintain district offices in the Terre Haute division at Grand Rapids and Owensboro. R. L. Fillner, former production superintendent at Findlay, has been appointed manager of the Grand Rapids district. J. J. McClelland, manager of the former Owensboro division, will remain in Owensboro as manager of operations in Kentucky, Tennessee, Ohio, Pennsylvania, Virginia, and West Virginia.

The Terre Haute division will be one of six operating divisions of the production department of The Ohio Oil Company. Other division offices are at Tulsa, Oklahoma, Shreveport, Louisiana, Houston, Texas, Casper, Wyoming, and Los Angeles, California.

Assumes new duties

C. L. Power has assumed the duties of development engineer for Dowell Incorporated's New Orleans district, covering South Louisiana, Mississippi, Alabama, and western Florida. Power has been with Dowell since 1936, serving the company in many varied assignments throughout the Gulf Coast area. For the past several years he has been development engineer for the district's Lafayette, Louisiana, station. His experience includes all operations of Dowell's oil field division, his particular interests being the development of new techniques in plastics and mud acid applications.

C. L. Power

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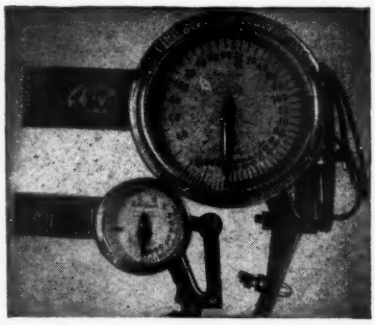

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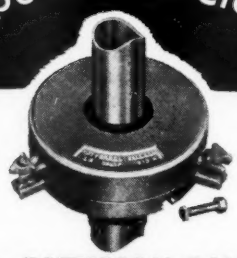

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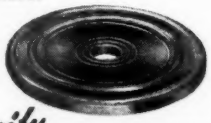

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At Compact Commission meeting

The above photographs were taken at the recent meeting in New York City of the Interstate Oil Compact Commission. In the top picture, left to right, are: Major General Ernest O. Thompson, chairman, Texas Railroad Commission; Max Ball, director, Oil and Gas Division, U. S. Department of Interior; William J. Murray, Jr., member, Texas Railroad Commission, and Olin Culberson, member, Texas Railroad Commission. Bottom picture, left to right: Governor Beauford Jester, Texas, chairman Interstate Oil Compact Commission; Governor James H. Duff, Pennsylvania; Governor Roy J. Turner, Oklahoma, and Governor Millard F. Caldwell, Florida.

Joins Stewart & Stevenson

W. B. Muse

Willard B. Muse has recently joined the staff of Stewart and Stevenson Services and is in complete charge of promoting Continental Red Seal engines in the state of Texas for that organization. For 17 years, Muse was associated with the Ford Motor Company sales promotion division, and for 10 years thereafter he was connected with the power unit business handling Continental engines. He was Southwest sales manager for Continental and initiated the establishment of a Continental distributor organization in seven states. He was also instrumental in pioneering the manufacture of power units and was one of the first to put a Continental engine on an air conditioning job.

In adition to handling Continental Red Seal engines, Stewart and Stevenson handles GM diesels and Packard marine engines and maintains one of the largest stores of industrial engine parts to be found anywhere in the world.

To distribute Rochester rope

Announcement has been made that "Homco," the Houston Oil Field Material Company, Inc., henceforth will be distributor for Rochester wire ropes throughout the oil country. Homco, which has 24 stores in Louisiana, Mississippi, New Mexico, Oklahoma, and Texas, will handle Rochester rope at every outlet. The complete Rochester line will be available, including Rochester "Wirelon," the nylon covered wire rope recently introduced by the Rochester company and which has attracted considerable attention because of its resistance to abrasion, rust, and corrosion.

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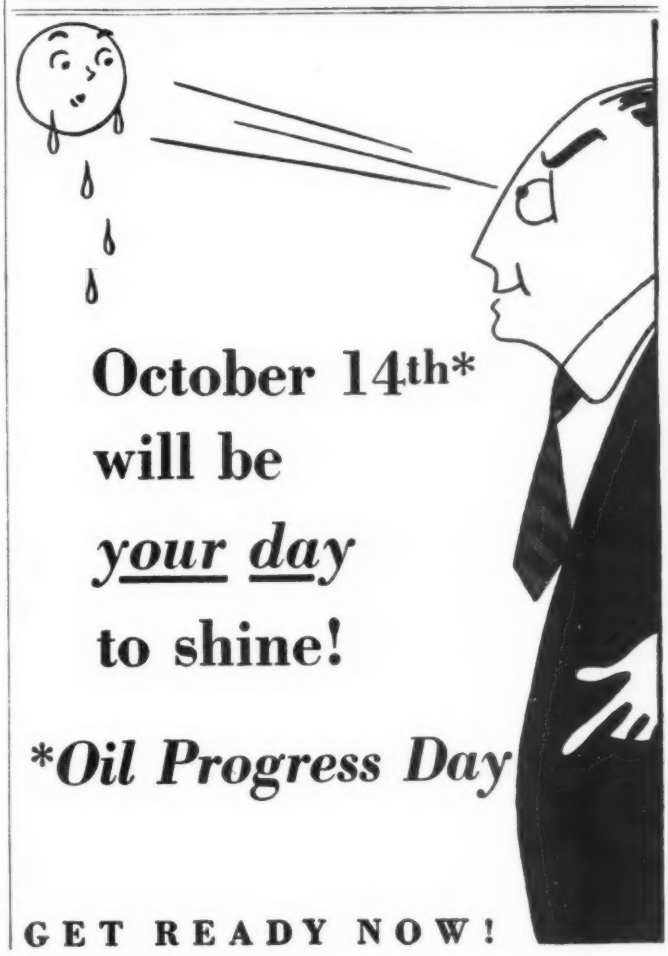

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Hydra-Line appoints key executives

Blaine Johnston, general manager of the Hydra-Line Division of Johnston Enterprises, announces the affiliation of George W. Sinclair as chief engineer, R. B. (Bob) Luirette as chief of quality control, and Carl H. Engelmohr as sales engineering manager.

Sinclair, who graduated from the California Institute of Technology, worked as engineer for the Reed Roller Bit Company in the 30's and later as chief engineer and shop superintendent for the Chester T. Allen Core Drilling Company in Bakersfield. During the war years he was associated with the Willys-Overland Company. Until his affiliation with Hydra-Line he had his own firm of consultant engineers.

C. H. Engelmohr

George Sinclair

R. B. Luirette

Luirette was formerly project engineer in charge of International Derrick and Equipment Company's Mid-Continent mobile rig development program. Previous to this experience he was an engineer in the California division of the same company. Prior to this he was engaged in precision hydraulic inspection. His new position charges him with the responsibility of all plant inspection, as well as field service work, both of a curative and preventive nature.

Engelmohr majored in marketing at the University of California at Los Angeles, and was, until recently, service manager for the western division of the International Derrick and Equipment Company. He has spent ten years in the oil fields of the Mid-Continent and California areas in sales and sales promotional work. Prior to that time he had been employed by the Carnegie-Illinois Steel Corporation in Chicago. His new duties include market analysis, advertising, publicity, and sales order division functions.

Makes Latin America tour

Earl Rees, popular export manager for Patterson-Ballagh is now spending five months in Mexico and South America. He is completing a field study of foreign needs in rubber oil field specialties such as casing protectors, pipe wipers, wire line guides, etc., in the western hemisphere.

Recently, Earl spent more than a month in Canada, checking drilling practices and supply company requirements. Valuable information regarding warehousing facilities, methods of buying, and actual drilling and production needs were obtained. He expects to obtain the same type of information on the southern leg of his tour of foreign fields.

He has been associated with the oil industry for the last 25 years and his many friends now in Latin American fields will be glad to see him as he covers Mexico, Venezuela, Trinidad, Bolivia, Argentina, Chile, Ecuador, Peru, Brazil.

Two promotions by Atlas

Two promotions at the Waco, Texas, plant of Universal Atlas Cement Company, a United States Steel Corporation subsidiary, have been announced from New York by L. M. Funderburg, vice president, operations, and F. P. Diener, chemical engineer.

Charles H. Dickens, chief chemist and inspector at the cement company's Waco plant, was appointed assistant plant manager. Harry W. Hunt, assistant chief chemist, was appointed to succeed Dickens as chief chemist and inspector.

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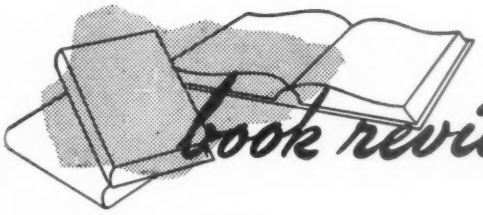

• **The Nature of Patentable Invention,** *by John E. R Hayes. Addison-Wesley Press, Inc., Cabridge 42, Massachusetts. Pages, 187. Price, $5.*

The attributes and definition of the nature of patentable invention are analyzed here by a member of the Boston Bar. The table of contents lists attributes, definition, mental concept, nature of ideas, analysis, considerations of physical attainment, identity and general rules of law. The mode of application and general information on claims are included. Briefs of cases provide concrete examples.

• **Pennsylvania Petroleum 1750-1872,** *A Documentary History, by Paul H. Giddens. Bureau of Publications, Commonwealth of Pennsylvania, Harrisburg. Pages, 420. Price, $1.50—paper bound; $1.75—cloth bound.*

Here is another engrossing, authentic history by Paul Giddens, the versatile curator of Drake Well Memorial Park. Focusing on the people and 'signs of the times,' he has compiled an enjoyable, and at times, highly amusing account of early oil days in Pennsylvania.

Letters, newspaper items, bills of sale, and personal accounts make you intimate with an old manner of living. Songs of the day show a popular, and often derisive, interest in the new industry. The contemporary accounts picture many facets of life in the 60's, from the social life in an oil town to the newest refining method. The reader receives a kaleidoscope view of the 19th century oil industry.

• **Synthetic Petroleum for the Synthine Process,** *by B. H. Weil and J. C. Lane. Remsen Press Division, Chemical Publishing Company, 26 Court Street, Brooklyn 2, New York. Pages, 303. Price, $6.75.*

This pioneer book on this method of preparing oil from natural gas, coal, and oil shale presents a detailed account of the technical and economic phases of the subject. Attention is given the theoretical and engineering phases of the process, with unusual emphasis on the nature and yield of products and by-products. Advances in German technology have been carefully scanned and discussed.

The subject is treated under four main headings: (1) Production and purification of the synthesis gas, (2) catalytic synthesis reactions, (3) products, by-products and derivatives, and (4) basic economies and current developments.

A classified list of over 2000 patents, an alphabetical indexed list of government reports, and a supplemental bibliography are included as an aid to further study.

Heads South American operations

Mud Products, Inc., Tulsa, Oklahoma, has named Harry F. Simons head of the firm's South American operations, it has been announced by E. R. "Dick" Albert, general manager of the organization.

Simons, a graduate of University of Tulsa and Oklahoma East Central Teachers College, has been connected with the drilling industry for the last 20 years, serving as roughneck, driller, and tool-pusher for a number of Mid-Continent drilling contractors.

In 1945, Simons engaged in sales and service engineering in South America for a foreign representative specializing in drilling and production machinery. Living in Bogota, Colombia, he covered Venezuela, Trinidad, Colombia, Ecuador, and Peru.

At present, Simons is conducting a trip through the South American territory to review the existing situation and to establish an organization to serve the customers of Mud Products, Inc., and the manufacturers it represents.

Simons, with his wife and three sons, will make their home and his business headquarters in Caracas, Venezuela.

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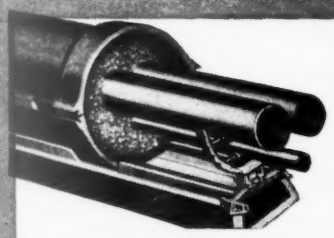
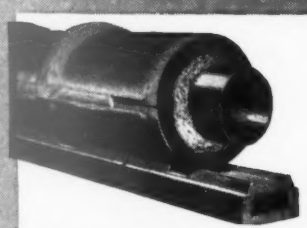


Standard Tile—for all normal ground load conditions.



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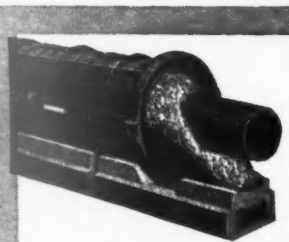

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DRILLING CONTRACTORS:

Here's the Shaffer Pressure Control Hook-Up that meets your every requirement for maximum safety, simplicity and wide-range adaptability. Check its many advantages . . . its all-around protection and versatility. You'll find it unsurpassed for modern drilling operations.

For continuous and automatic pressure control while drilling —

THE SHAFFER COMBINATION ROTATING BLOW-OUT PREVENTER AND STRIPPER

No matter how sudden the pressure emergency, it can't happen too fast for this pressure control unit *because it is always packed off around the drill string as long as pipe is in the hole!*

No levers or valves to operate. No time delay. It maintains its pressure-tight seal *continuously,* even around varying diameters and shapes. These are a few of its many unique features . . .

ANY SHAPE! The Stripper Rubber automatically expands and contracts to maintain a tight seal around any diameter in the drill string (except for such abnormally large diameters as reamer and bit). It seals off around the kelly, whether square, hexagonal or octagonal . . . and around the varying diameters of drill pipe, couplings, tool joints and drill collar. Adjustment to different diameters and shapes is completely automatic — no manual operations are necessary.

CONTINUOUS SEAL! Not only does the Stripper Rubber seal off around any shape or diameter in the drill string, but its automatic and instant adjustment to varying shapes and sizes permits the drill string to be stripped in and out of the unit without losing seal at any time. Pipe is run into the hole and removed with the same convenience and simplicity as in conventional drilling operations.

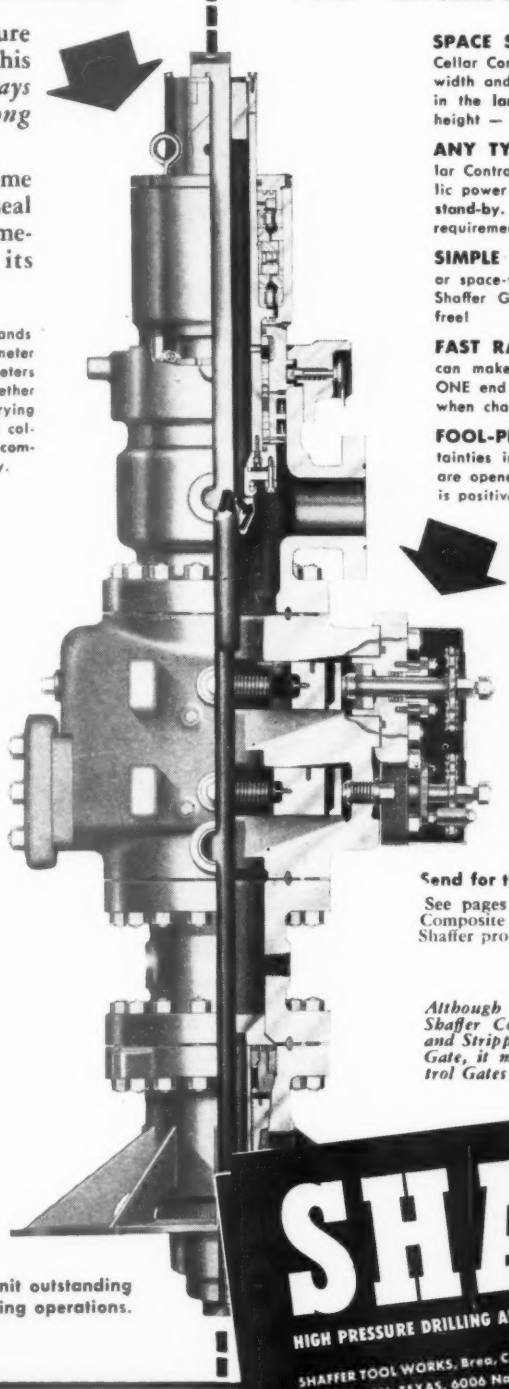
MINIMUM WEAR! Since the Stripper Rubber rotates with the kelly — not around it — there is practically no wear on the rubber. Maintenance is negligible.

QUICK RELEASE! When running such large tools as the bit or reamer through the unit, simply pull a spring latch, rotate the bonnet 1/6th turn and the complete rotating assembly is readily withdrawn from the body on top of the bit or reamer. When going back into the hole simply reverse the operation. It's quick and simple!

UNUSUALLY COMPACT! The Shaffer Combination Rotating Blow-Out Preventer and Stripper is so engineered that vertical height in the drilling riser is kept at a minimum. In addition, flow connections built directly into the body eliminate need for spools or other accessories for overflow connections, thus saving still more space.

STEEL PROTECTED RUBBER! Note how the Stripper Rubber is backed by flexible steel latches (A) which form an expandable steel barrier to prevent extrusion when the rubber is subjected to unusually high pressure or to abnormal expansion. This flexible steel barrier so protects the rubber that large diameters can be pulled through it without damage . . . and even extremely high well pressures will not cause the rubber to extrude.

There are many other features that make this unit outstanding for highest efficiency and safety in modern drilling operations. Write for the complete details.



For complete shut-off whether drill string is in or out of well . . .

THE SHAFFER DOUBLE CELLAR CONTROL GATE

This unit not only provides complete shut-off of open hole, but also seals around the drill string to provide added protection and safety when blow-outs threaten while pipe is in the hole. Note its compactness and fool-proof dependability — how it can be easily adapted to varying power requirements — and other outstanding advantages . . .

SPACE SAVING COMPACTNESS! All-Shaffer Cellar Control Gates are unusually compact in length, width and height. And the Shaffer Double Gate, even in the largest size, requires less than 29" of cellar height — smaller sizes even less!

ANY TYPE POWER! You can operate Shaffer Cellar Control Gates with air, steam, electric or hydraulic power drives — plus the added safety of manual stand-by. There's a choice of power to meet every well requirement!

SIMPLE INSTALLATION! No complicated piping or space-wasting pressure manifolding is required for Shaffer Gates. Installation is simple, clean, clutter-free!

FAST RAM CHANGES! With Shaffer Gates you can make a complete ram change by removing just ONE end cover. Saves time and simplifies operations when changing from one pipe size to another!

FOOL-PROOF OPERATION! There are no uncertainties in operating Shaffer Gates because the rams are opened and closed by direct mechanical drive. It is positive and trouble-free!

NON-CREEPING RAMS! Only one quick operation is required to close the Shaffer Gate — and keep it closed. No auxiliary locking devices or extra operations are necessary because Shaffer rams automatically stay in whatever position they are set. This means extra safety in emergencies!

Shaffer, pioneer of modern pressure control equipment, also offers a complete range of control equipment in addition to the units shown above . . . Shaffer Kelly Cocks, Shaffer Adjustable Flow Beans, Shaffer Landing Heads, Tubing Heads, and other control equipment . . . plus a complete line of field-proven fishing tools.

Send for the complete Shaffer Catalog!

See pages 3843 to 3894 of your 1947 Composite Catalog for more details on Shaffer products.

Although the above Shaffer Hook-Up shows the Shaffer Combination Rotating Blow-Out Preventer and Stripper with the Shaffer Double Cellar Control Gate, it may also be used with Shaffer Single Control Gates in any arrangement, if desired.

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JULY 1 • 1948

VOLUME XIX NUMBER 10

MEETINGS

Aug. 30-Sept. 1—Interstate Oil Compact Commission, Roosevelt Hotel, New York City.
Aug. 30-Sept. 1—Appalachian Gas Measurement Short Course, West Virginia University School of Mines, Morgantown, N. Y.
Sept. 1-2—Oil Industry Information Committee, Minneapolis, Minn.
Sept. 6—Nomads, Louis Sherry's, 50th Street and Park Avenue, New York City.
Sept. 6-10—American Chemical Society, Petroleum Division, fall meeting, St. Louis, Mo.
Sept. 7-9—SAE, Tractor and Diesel Division, Schroeder Hotel, Milwaukee, Wis.
Sept. 9-11—Compressed Gas Mfrs Assn, Canadian Sec, Manor Richelieu, Murray Bay, Quebec, Canada.
Sept. 12-14—Southwest LP Gas Convention, Skirvin Hotel, Oklahoma City.
Sept. 13-17—Instrument Society of America, conference and exhibit, Convention Hall, Philadelphia, Pa.
Sept. 14-16—Pacific Coast Gas Assn, annual meeting, Hotel Casa del Rey, Santa Cruz, Calif.
Sept. 15-17—API, Lubrication Committee, Hotel Traymore, Atlantic City, N. J.
Sept. 15-17—AIChE, French Lick Springs Hotel, French Lick, Ind.
Sept. 16-18—NPA, Hotel Traymore, Atlantic City, N. J.
Sept. 17—Oklahoma Utilities Assn, Gas Div., Biltmore Hotel, Oklahoma City.
Sept. 21—New York Nomads, golf party, Baltusrol Country Club, New Jersey.
Oct. 4-6—AIME, Petroleum Division, fall meeting, Adolphus Hotel, Dallas, Texas.
Oct. 4-9—AGA, technical section, annual meeting, Ambassador Hotel, Atlantic City, N. J.
Oct. 4-9—American Association of Petroleum Geologists, midyear meeting, Pittsburgh, Pa.
Oct. 11-13—National Lubricating Grease Institute, annual meeting, Edgewater Beach Hotel, Chicago, Ill.
Oct. 11-13—American Assn of Oilwell Drilling Contractors, annual meeting, Rice Hotel, Houston, Texas.
Oct. 12-16—National Chemical Exposition and National Industrial Chemical Conference, Coliseum, Chicago, Ill.
Oct. 14-15—AIME, Petroleum Division, Elks Club, Los Angeles, Calif.
Oct. 14-15—Texas Mid-Continent Oil & Gas Assn, annual meeting, Blackstone Hotel, Fort Worth.
Oct. 23-29—American Society of Metals, annual meeting, Benjamin Franklin Hotel, Philadelphia, Pa.
Oct. 25-28—AIME, Metals Division, Hotel Adelphia, Philadelphia, Pa.
Oct. 25-29—American Welding Society, Bellevue-Stratford Hotel, Philadelphia, Pa.
Nov. 8-11—API, annual meeting, Stevens Hotel, Chicago, Ill.
Nov. 15-18—American Oil Chemists Society, fall meeting, Pennsylvania Hotel, New York.

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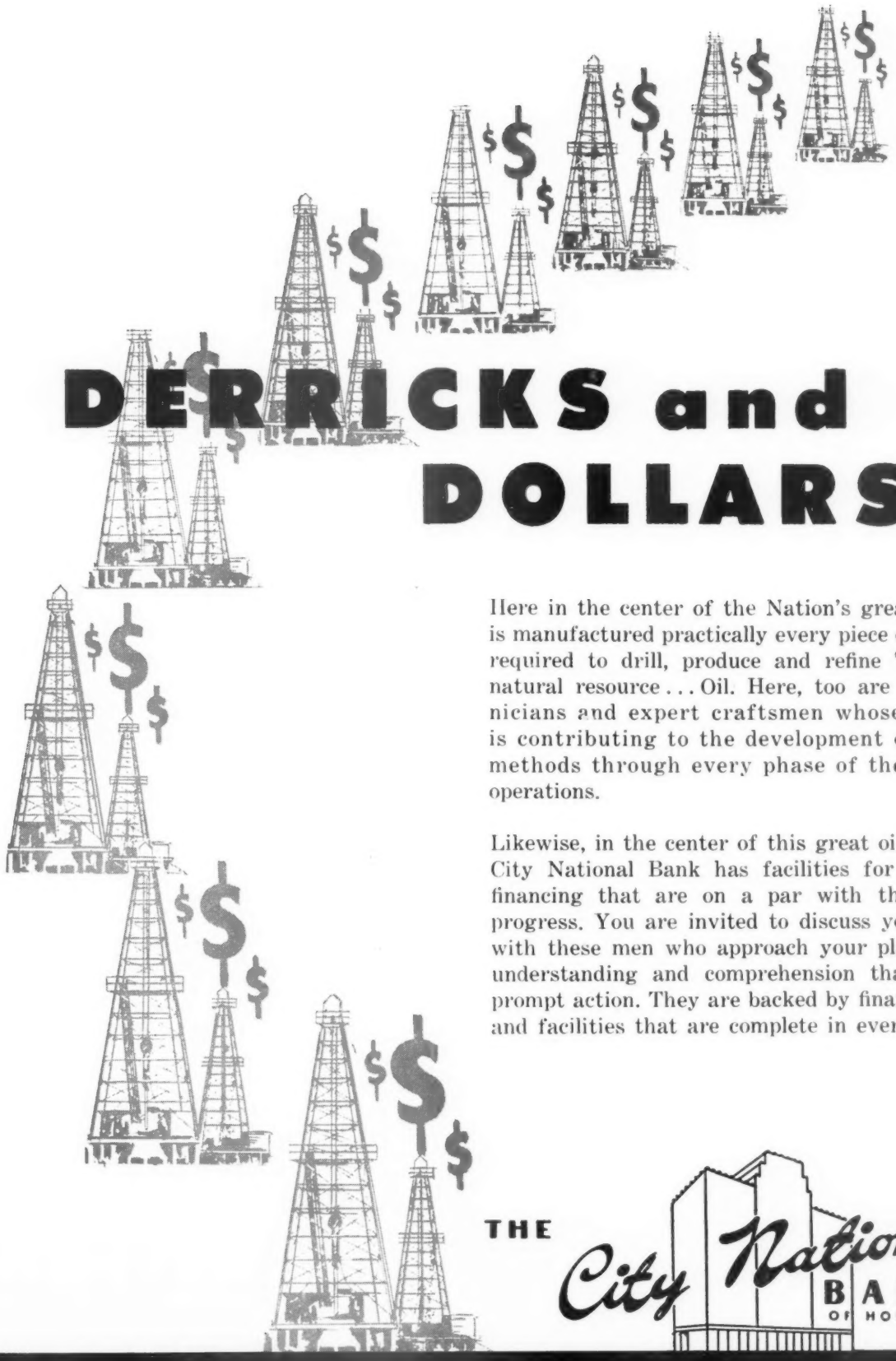

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